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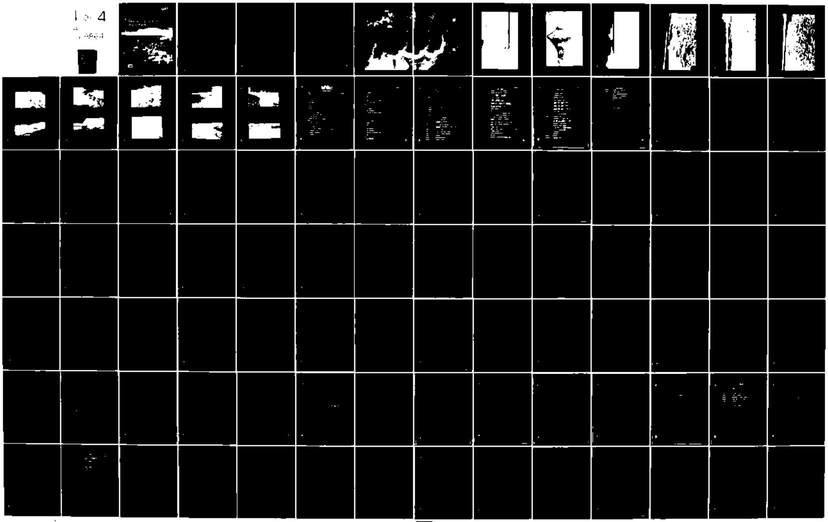

Detailed Project Report
And Environmental Assessment

West Beach
Westport, Conn.

ADA119864

Sherwood Island State Park

SEPTEMBER 1981

US Army Corps of Engineers
New England Division

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SECTION 103 SMALL BEACH EROSION CONTROL REPORT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Detailed Project Report present results of an analysis of beach erosion problems at Sherwood Island State Park, and investigated several alternative plans of erosion control for West Beach, the Sherwood Island State Park. Recommended beach widening by placement of sandfill along 1800 feet; also lowering of the landward portion of existing groin structure and the construction of another groin structure.

SYLLABUS

This Section 103 Small Beach Erosion Control Report was prepared at the request of the State of Connecticut. The study area consists of 1,800 feet of shoreline at Sherwood Island State Park West Beach, Westport, Connecticut. The purpose of this study is to investigate the beach erosion control needs for the area.

Sherwood Island State Park is a 200-acre park owned and operated by the State of Connecticut. The park consists of two distinct beach areas, East Beach and West Beach, which are separated by a rocky headland known as Sherwood Point. West Beach has been experiencing severe erosion over the years; however, East Beach has remained relatively stable. Therefore, this study will concentrate only on West Beach.

A beach erosion control study was completed by the Corps of Engineers in 1949, in cooperation with the State of Connecticut. This study investigated the Connecticut shore between Ash Creek and the Saugatuck River, which includes the Sherwood Island State Park area. The report recommended the placing of sandfill along 6,000 feet of Sherwood Island State Park shoreline, and the construction of one groin at the west end of the beach and two timber training walls at the east end of the beach to protect and improve the beach for recreational use. Construction of this work was completed in June 1957.

The rapid loss of sand at Sherwood Point caused the State to request a restudy in 1966. This restudy led to a resolution, adopted in May 1968 by the Committee on Public Works of the United States Senate, requesting that the Board of Engineers for Rivers and Harbors (BERH) review the 1949 report to determine whether or not any modifications should be made to the original plan. The Corps completed a report in November 1974 and forwarded it to the BERH for review, recommending that a modification of the authorized 1949 plan was advisable. No final action was taken by the Board at that time because of the State's failure to meet the items of local cooperation.

The State of Connecticut requested, in January 1979, that the Corps complete the Sherwood Island Project, because the condition of the beach was worsening and they were now in a position to meet the requirements of local cooperation. A reconnaissance report was completed in June 1980. The report stated that due to the State's improvements at Sherwood Point, the recommendations as stated in November 1974 report could be reduced and that the work along the East Beach was no longer necessary. The reconnaissance study determined that a detailed study of only West Beach was feasible.

This Detailed Project Report investigated several alternative plans of erosion control for West Beach. As a result of this study it was determined that the following plan, Plan 3, was the most feasible plan of improvement:

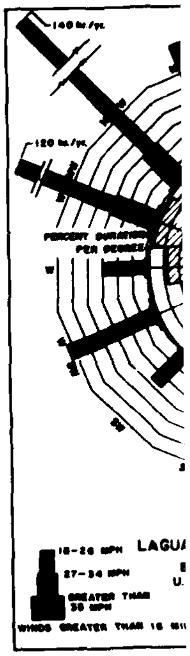
Beach widening by the direct placement of suitable sandfill along 1,800 feet of West Beach, extending east from the existing Federal

groin structure to Sherwood Point. Also included is the lowering of the landward portion of the existing groin structure and the construction of an intermediate low-profile groin structure approximately 900 feet west of Sherwood Point.

This plan will provide a 200-foot level beach berm width and a useable dry beach space of approximately 275 feet above the mean high waterline.

The Division Engineer recommends that, subject to certain conditions of non-Federal cooperation, the recommended plan be authorized as a beach erosion control project under Section 103 of the River and Harbor Act of 1962, as amended. The estimated first cost of construction for this project is $960,000, which includes the first year of periodic nourishment, and is to be borne jointly by the United States and the State of Connecticut. The Federal share is estimated at 70 percent or $672,000, and the non-Federal share is estimated at 30 percent or $288,000. Annual charges are $95,000 and the annual project benefits are $734,800 providing for a benefit-cost ratio of 7.73. These cost-sharing figures include periodic nourishment and are subject to approval by the Chief of Engineers. Conditions of local cooperation must also be met.


STUDY AREA
LONG ISLAND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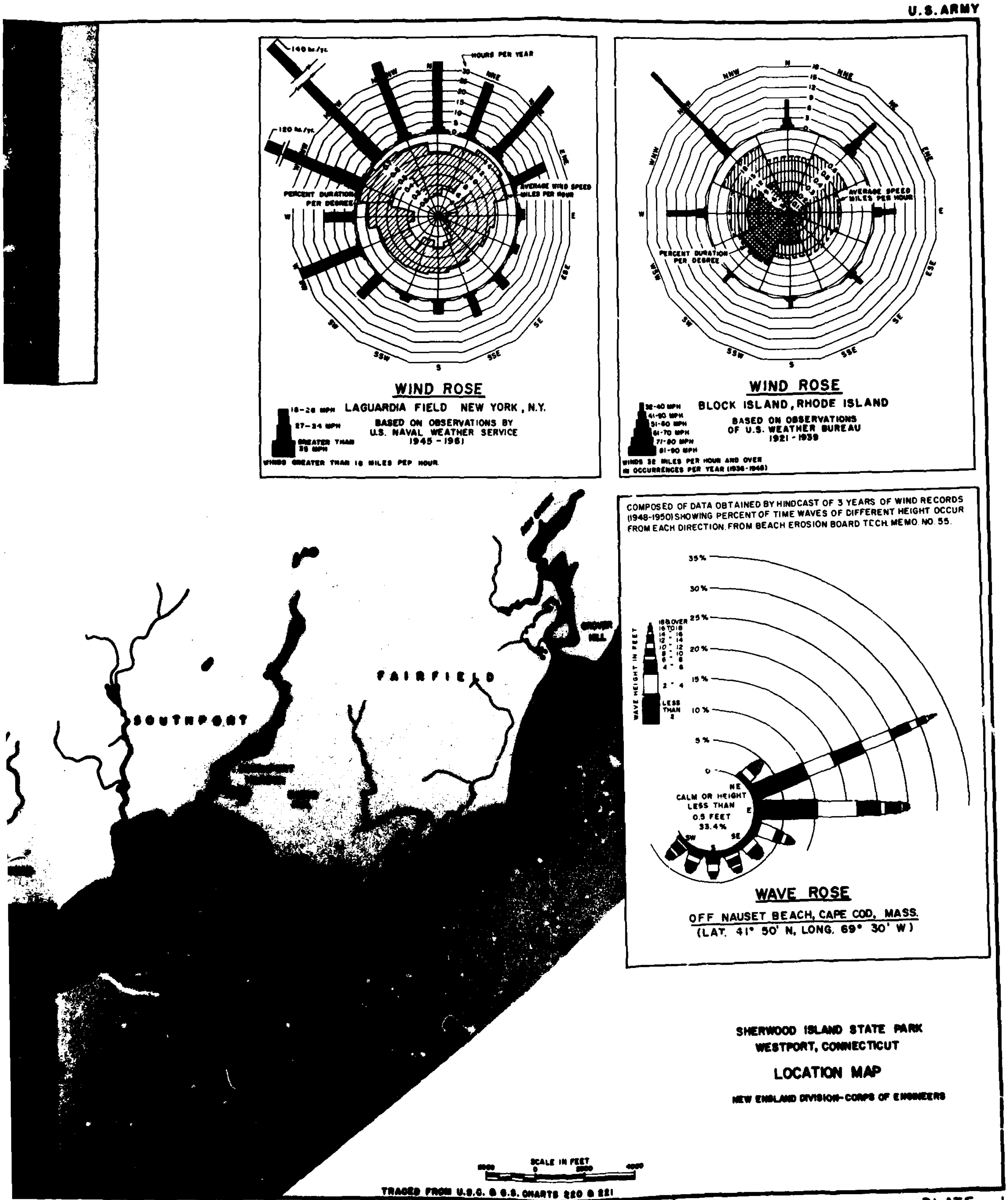
U.S. ARMY
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120 hr./yr.
AVERAGE WIND SPEED MILES PER HOUR
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WIND ROSE
LAGUARDIA FIELD NEW YORK, N.Y.
BASED ON OBSERVATIONS BY U.S. NAVAL WEATHER SERVICE 1945 - 1961
WINDS GREATER THAN 16 MILES PER HOUR.
AVERAGE SPEED MILES PER HOUR
PERCENT DURATION PER DEGREE
WIND ROSE
BLOCK ISLAND, RHODE ISLAND
BASED ON OBSERVATIONS OF U.S. WEATHER BUREAU 1921 - 1939
COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION. FROM BEACH EROSION BOARD TECH. MEMO. NO. 55.
WAVE HEIGHT IN FEET
CALM OR HEIGHT LESS THAN 0.5 FEET 33.4%
WAVE ROSE
OFF NAUSET BEACH, CAPE COD, MASS.
(LAT. 41° 50' N, LONG. 69° 30' W)
FAIRFIELD
SOUTHPORT
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
LOCATION MAP
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
SCALE IN FEET
TRACED FROM U.S.C. & G.S. CHARTS 220 & 221

PLATE 1

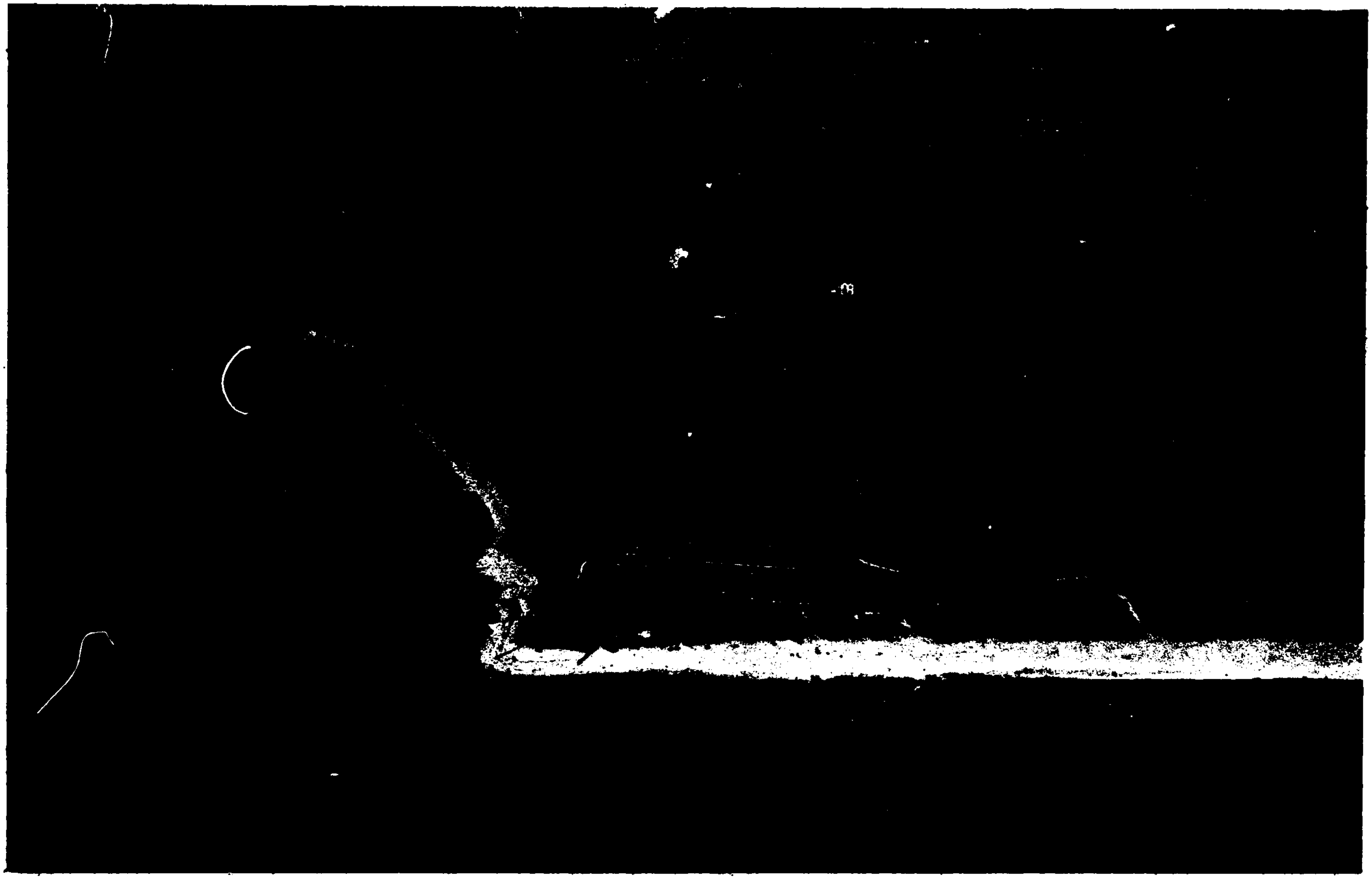

PHOTO 1 . Pre-construction aerial view looking northwest along Sherwood Island State Park beach. Note, no suitable bathing beach at point and along westerly shorefront. (1955)

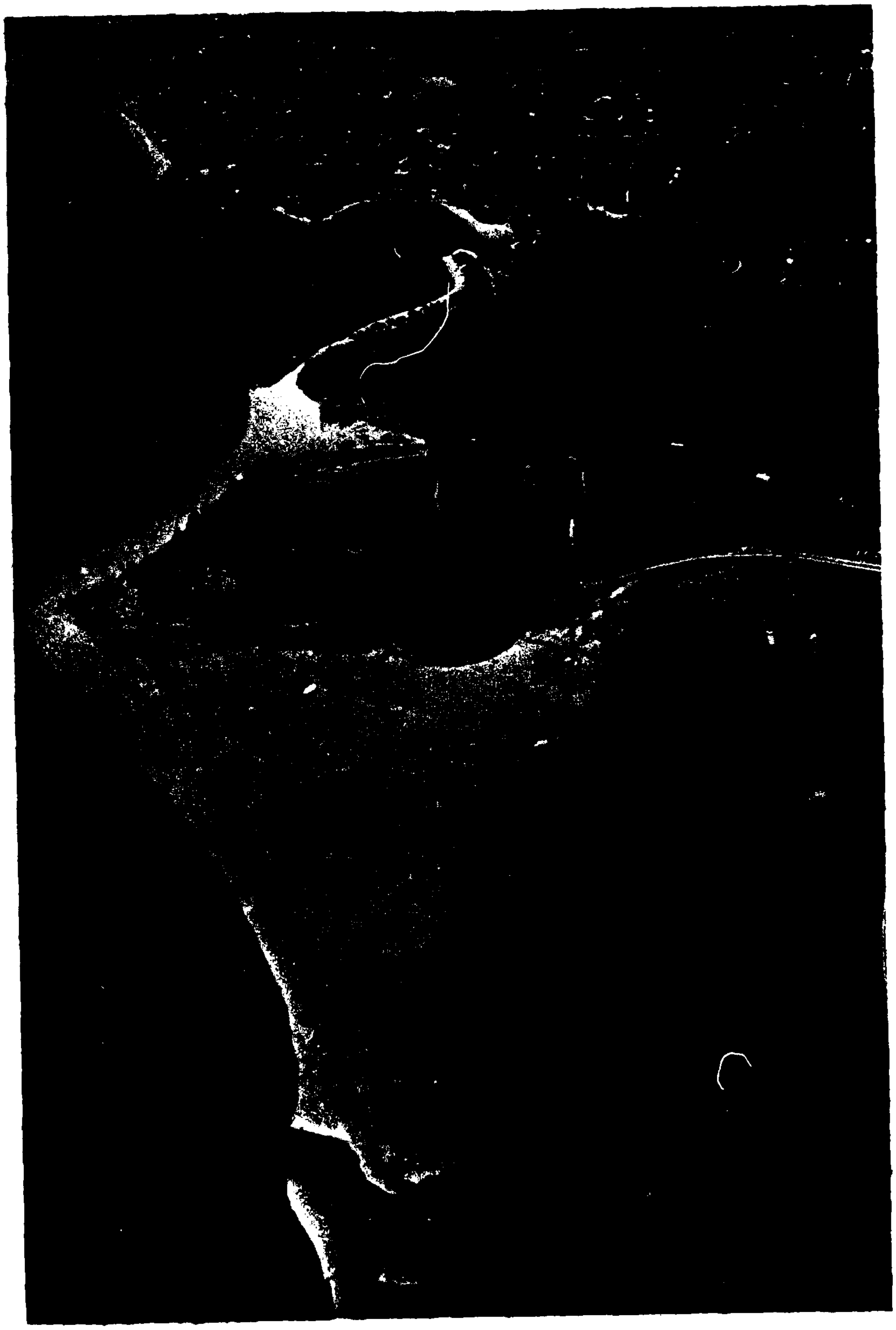

PHOTO 2 . Post construction aerial view of Sherwood Island Park beach, immediately following construction. Note, wide protective recreational beach throughout. (1957)

PHOTO 3 . At point looking inland toward pavilion. Large boulders and rocks now prevail. Erosion of embankment is rapid requiring revetment of about 1200 feet of lawn fronting pavilion. (1965)

PHOTO 4 . Looking northeast along point and East Beach. Most of sand placed at and 1000 feet each side of point in 1957 as a protective measure and stockpile for natural beach nourishment is now lost. East Beach is the sandy area in the background. (1972)

PHOTO 5 . Looking northwest toward westerly terminal groin structure. The beach has now eroded to make much of West Beach unsuitable for bathing and inefficient as a protective improvement. (1972)

PHOTO 6 . Looking northwest along West Beach portraying the extremely rocky condition now existing at the point and along much of West Beach. (1972)

PHOTO 7 - Sherwood Point which separates East Beach and West Beach.

PHOTO 8 - Looking west from Sherwood Point along West Beach. Note lack of available dry beach space.

PHOTO 9 - Looking east along West Beach towards Sherwood Point. Note large stones placed to protect erosion of backshore and picnic area.

PHOTO 10- Closer look at erosion of backshore and large stones placed to prevent further erosion.

PHOTO 11 - Looking west from Sherwood Point along West Beach. Note configuration of shoreline.

PHOTO 12 - Closer look at erosion and shoreline configuration. Note temporary build-up of material adjacent to erosion area.

PHOTO 13 - Looking along erosion area towards Federal groin structure. Note lack of dry beach space.

PHOTO 14 - Closer look at Federal groin structure. Note rocky conditions of foreshore area.

PHOTO 15 - Looking at the State land on the west side of the existing Federal groin structure. Note that this area has been starved by the raising of the groin.

PHOTO 16 - Looking from ocean side at the east tidal gate for Sherwood Mill Pond.

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WEST BEACH
SHERWOOD ISLAND STATE PARK
DETAILED PROJECT REPORT

INTRODUCTION

This Detailed Project Report presents the results of an analysis of the beach erosion problem at Sherwood Island State Park. Sherwood Island State Park is located in Westport, Connecticut, approximately 10 miles west of Bridgeport, Connecticut and 50 miles east of the city of New York. The park is one of Connecticut's favorite recreational areas. The beach is separated, by Sherwood Point, into two distinct bathing areas, known as East Beach and West Beach. The beaches have been overtopped during frequent serious winter storms. However, over the years East Beach has remained relatively stable; therefore, this study will concentrate on West Beach.

STUDY AUTHORITY

In a letter dated 19 January 1979, Governor Ella Grasso requested that the Sherwood Island State Park beach erosion control study be completed. The study and construction, subject to approval, is authorized under Section 103 of the River and Harbor Act of 1962, as amended for Small Beach Erosion Control Projects.

SCOPE OF STUDY

The scope of this study consists of evaluating approximately 1,800 feet of the Sherwood Island State Park West Beach shoreline for beach erosion control. The damages that storm winds and waves cause to the shoreline were investigated along with alternative plans for providing shore protection, encouraging healthful recreational beach bathing, and preventing future damages due to the natural elements. A detailed analysis was conducted of all the elements necessary for successful economic water resource planning for the study area, including detailed studies of the social and environmental features of the area, associated construction costs for the considered plans, and other related matters.

STUDY PARTICIPATION AND COORDINATION

Throughout the course of the study, close coordination was maintained with Federal, State, and town officials as well as the general public. All phases of the study were coordinated with the U.S. Fish and Wildlife Service, various organizations within the Department of Environmental Protection, and State Marine Fisheries Service. Contact was made with the Coastal Engineering Research Center to obtain assistance in choosing the best possible method to use to determine the coastal processes in Long Island Sound. State and town officials, representatives of the organizations mentioned above, and the public were kept informed as to the progress of the study.

OTHER STUDIES AND REPORTS

The Corps of Engineers, in cooperation with the State of Connecticut, completed a beach erosion control report for the reach of shorefront between Ash Creek and the Saugatuck River in 1949. This report is published in House Document No. 454, 81st Congress, 2d Session.

Published in House Document No. 412, 87th Congress, 2d Session is an interim hurricane survey report, completed in 1961, for Westport, Connecticut. This report recommended Federal participation in a hurricane protection project for the nearby Compo Beach area. A second interim hurricane survey report was completed for Connecticut coastal and tidal areas in 1964. This report is published in House Document No. 146, 89th Congress, 1st Session.

The Coastal Engineering Research Center completed in May 1967, Technical Memorandum No. 20, "Behavior of Beach Fill and Borrow Area at Sherwood Island, Westport, Connecticut." This technical study reviewed the existing problems at Sherwood Island and made recommendations for improvements.

In June 1968, the Corps completed a reconnaissance report in response to the request of 5 January 1966 from the Water Resources Commission, State of Connecticut (now called the Department of Environmental Protection). This report was completed in accordance with the authority of Section 103 of the River and Harbor Act of 1962, as amended by Section 310 of the River and Harbor Act of 1965. The report recommended that a full scope beach erosion control survey report be undertaken.

A beach erosion control study of Sherwood Island was undertaken by the Corps of Engineers in November 1974. This included a review of the 1949 report completed by the Corps in cooperation with the State of Connecticut. The study was deferred due to lack of local cooperation.

A study of shoreline stabilization at Sherwood Island State Park and the Compo Cove area was performed, for the State of Connecticut, by Flaherty Giavara Associates, P.C. and Raytheon in September 1979. This study also looked at the restoration of Sherwood Mill Pond. Recommendations were made for improvements to existing structures and the addition of new structures.

THE REPORT AND STUDY PROCESS

The main report is the base document, presenting the broad view of the overall study. Through the main report, the nontechnical reader is provided with a view of the problems and needs of the study area as well as a discussion of the recommendations and conclusions. The appendices contain data and details, both technical and nontechnical, and are supporting documents for the main report.

In June 1980, a reconnaissance report, which is the culmination of the first stage of the study process, was completed. The reconnaissance report reviewed the problems and determined that further analysis and completion of the study was warranted.

The second and final stage of the study process is concluded with this Detailed Project Report. This report defines in detail the problems and needs of the area and outlines detailed alternative plans. These plans are based on environmental constraints and detailed engineering and design considerations. A recommendation, based on the above criteria and on a benefit-cost ratio, is made for a selected plan. The State of Connecticut has received and reviewed the Draft Detailed Project Report.

PROBLEM IDENTIFICATION

This section of the report presents the problems and needs of the beach area, both present and future. Problem and opportunity statements are developed through studying the problems and needs in conjunction with the planning constraints. The analysis of plans takes into account the requirements of the national objectives and other planning tasks.

NATIONAL OBJECTIVES

The Principles and Standards procedures, established by the U.S. Water Resources Council, require that the national objectives be examined for each alternative plan to determine the impacts on the total environment. The national objectives investigated are National Economic Development (NED) and Environmental Quality (EQ). These two objectives

are assigned equal importance during the planning process. Consideration is also given to Regional Economic Development (RED) and Other Social Effects (OSE).

The two major goals considered in the development of the alternative plans are:

NED Objective - To increase the nation's output of goods and services and to improve economic efficiency in order to enhance the National Economic Development (NED).

EQ Objective - To enhance the Environmental Quality (EQ) through the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural, cultural, and ecological resources.

EXISTING CONDITIONS

Sherwood Island State Park is owned and operated by the State of Connecticut, and is divided by Sherwood Point into two distinct beach bathing areas known as East Beach and West Beach. Other than the beaches, facilities in the state park include such items as a pavilion containing a restaurant, a bathhouse, sanitary facilities, picnic tables, ball playing areas, and large grassy areas.

State officials estimate that 90 percent of the visitors to the park use the beach while the other 10 percent use the backshore facilities. The East Beach has remained relatively stable over the years; therefore, West Beach is the only beach that this study will cover. The West Beach extends for approximately 1,800 feet between Sherwood Point and an existing Federal groin structure. To the west of the Federal groin structure is a small portion of State beach, then a private beach area known as Compo Cove Beach. (See Plate 1.)

There is little or no dry beach bathing area above the mean high waterline on sections of the West Beach near Sherwood Point. However, the western portion of the beach is approximately 100 feet wide above the mean high water line and very heavily used. Due to the effects of the tides, winds, waves, storms, hurricanes, and littoral drift, the West Beach has been experiencing a serious erosion problem over the years.

There are oyster beds located about 1,000 feet offshore. There is some evidence of clams, mussels, and snails in the nearshore area, however, since this is a high energy area the number is very small. The Westport Shellfish Officer has reported that the area is only used for beach bathing and is closed for clamming and although there are some clams available, this is not a viable resource.

Sherwood Island State Park is open to the general public, for a nominal fee, and is easily accessible to residents of much of Connecticut and the New York City area. Due to the fact that Sherwood Island is the most convenient beach for the residents of the New York City area, and because most of the other beaches in the vicinity of Sherwood Island are open only to residents, the majority of the visitors (75 percen) to the park are residents of New York. The park is a very popular recreational area; however, due to the erosion that has occurred over the years, combined with the beach's popularity, an overcrowding condition now exists.

CONDITION IF NO FEDERAL ACTION TAKEN

Erosion is occurring on the eastern portion of West Beach of Sherwood Island State Park, while the western portion of the beach near the Federal groin structure is fairly stable. If a beach restoration program is not undertaken by the Federal government, the erosion of the eastern portion of the beach will continue and will eventually result in the loss of valuable shorefront property. The stability of the western portion of the beach will continue, to a point, then erosion will take over and some sort of an equilibrium will be reached. This point of equilibrium will in no way supply the needed dry beach space. The State of Connecticut is regrading the beach periodically and will continue to do so as long as their budget allows. This regrading, however, does not include the addition of any sandfill; therefore, it does not make up for the loss of sandfill nor does it help control the erosion. Eventually, if no Federal action is taken, the deterioration of the West Beach of Sherwood Island State Park will result in the loss of valuable shorefront property, causing a loss of income to the State. Another problem is that as the land is lost, the wave action causing the erosion may carry the material out, possibly impacting the offshore oyster beds.

PROBLEMS, NEEDS, AND OPPORTUNITIES

Due to the fact that the erosion is allowed to continue, the backshore picnic area is eroding and the beach fronting this area is gone, as a result the available dry beach space has decreased, which results in more overcrowding. Eventually, the overcrowding will be such that people will try to find other beaches to visit. With the beach users attempting to find other beaches to visit, the State will suffer a loss of income from both the fee to use the beach and from the restaurant. Most of the other beaches in the area are either privately or locally owned and are not open to the general public; therefore, the nonresidents who visit Sherwood Island State Park are not left with many alternate beaches to visit. Another problem caused by the continued erosion is one of safety to the bathers. The nearshore is very rocky and several bathers have

suffered from rock bruises and cuts. As the erosion continues, more rocks are exposed and the potential for injury increases. There is a definite need for more available dry beach space at the park.

The rocky nearshore is not only a source for safety problems, it is also a source for visual problems since it is not aesthetically pleasing to the eye. This area is also a limited shellfish area between mean high water and mean low water. This area, however, is not considered a viable resource area.

PLANNING CONSTRAINTS

Consideration was given to many concerns in developing the considered plans of improvement, but only a few of these concerns are identified as constraints.

Planning constraints are limitations that are taken into consideration in the planning process. These limitations are based on a wide range of concerns, such as natural conditions, social and environmental factors, economic limits, and legal restrictions.

The following constraints were found to be relevant to the study:

Avoid adverse effects on the nearshore fishing areas. This area contains popular fishing areas.

Avoid adverse effects on adjacent shore configurations. Any work performed on this beach must not cause deterioration to any adjacent beaches.

The State's financial capabilities are limited, therefore, the plans that are formulated should not put unreasonable financial burdens on the State.

PROBLEM AND OPPORTUNITY STATEMENTS

Problem and opportunity statements define water and related land resource management needs that can enhance National Economic Development (NED) and Environmental Quality (EQ). These needs, which include national, State, and local needs, are specific to a given area. Problem and opportunity statements are derived from known areas of public concern and from anticipated "without project" conditions that are likely to occur. Based on these items, the following problem and opportunity statements were established for the 50-year period of analysis:

- Contribute to the safety of the users of the beach.
- Contribute to the economic strength and well-being of the area.
- Preserve the environmental quality of the area.
- Contribute to the continued recreational use of the beach.
- Contribute to the stability of the beach.

FORMULATION OF PRELIMINARY PLANS

Consideration was given to both structural and nonstructural solutions in formulating alternative plans for Sherwood Island. In formulating these plans, engineering, economic, environmental, and social factors were studied to arrive at the best solution. Plans were developed to identify and minimize conflicts to the greatest extent possible. Public meetings were held with State, regional, and local officials for their preferences and desires in arriving at the selected plan of improvement.

MANAGEMENT MEASURES

As a basis for formulating alternative plans, a broad range of management measures were examined for possible solutions to the problems at Sherwood Island. Structural as well as nonstructural alternative measures were considered. Such nonstructural measures included:

a. Do nothing approach, allow the beach and backshore to continue to erode naturally.

b. Improve backshore park and other recreational facilities.

c. Dune restoration with grass planting.

d. Improve shoreline conditions to reduce the threat of injury to bathers by alleviating the rocky conditions.

e. Limit the number of beach bathers on peak days.

f. Restrict fishing to the areas designated by the State Marine Fisheries and allow swimming only in areas away from other activities.

Structural measures included:

a. Place suitable sandfill along the entire beach area.

b. Construct groin structures to compartmentalize the beach.

c. Construct an offshore breakwater.

d. Place rock revetment along the backshore.

e. Improve the deteriorated Federal groin structure as needed.

PLAN FORMULATION RATIONALE

Alternative plans were developed from different management measures. Formulation leading to the selection of the recommended plan included an evaluation of the NED, EQ, OSE, and RED accounts in arriving at the best plan of protection for Sherwood Island. Input for improvement came through public contacts with State, regional, local and concerned interests. These plans were evaluated according to the Principles and Standards of the Water Resources Council.

PLANS OF OTHERS

At this time, there is a study being undertaken by a contractor for the State of Connecticut for the Compo Cove area. The plan of improvement for Compo Cove Beach consists of beach widening by the direct placement of suitable sandfill, the construction of two low-profile groins on the beach, and one structure on either side of the entrance to the inlet. Sandfill will also be placed on Old Mill Beach. No work is scheduled to be done in Sherwood Pond.

ANALYSIS OF PLANS CONSIDERED IN PRELIMINARY PLANNING

All of the alternative plans developed below address a broad range of publicly held concerns. Economic, environmental, and social needs were considered in the formulation of these plans as well as in solving water and related land resource problems. Each plan was screened for feasibility and justification during the study and, depending on the conclusion, was either recommended for further detailed analysis or eliminated from the study.

DESCRIPTION OF PLANS

Various plans were studied and analyzed throughout the planning process. Structural and nonstructural plans were such methods used in the study of correcting the problem of the eroding shoreline and beach and to provide more usable beach space for the public. As stated previously, suggestions and recommendations from interest groups were used in formation of these plans. The following is a brief description of the plans considered:

(The three plans containing sandfill were considered with three possible beach berm widths: 200, 225, and 250 feet.)

Plan 1 - This plan consists of widening the existing beach to the three level berm widths by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline extending from the east limit of study at Sherwood Point to the west limit of study at the existing Federal groin structure.

Plan 2 - This plan consists of widening the existing beach, to the three level berm widths by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, and lowering the landward end of the existing Federal groin structure.

Plan 3 - This plan consists of widening the existing beach to the three level berm widths by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, lowering the landward end of the existing Federal groin structure, and constructing a low-profile groin structure located approximately 900 feet west of Sherwood Point.

Plan 4 - Shore management planning guidelines. This involves planning guidelines for managing the use of the backshore facilities and providing additional planning guidance for future public participation in water related activities. This plan includes such items as restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dunes.

Plan 5 - This plan consists of constructing an offshore breakwater located 600 feet in front of the West Beach.

Plan 6 - This plan consists of placing rock revetment along the entire length of backshore along the West Beach extending between the west groin structure and Sherwood Point.

COMPARATIVE ASSESSMENT AND EVALUATION OF PLANS

It was generally agreed by Federal, State, regional, and local interests that some degree of protection for Sherwood Island was needed. Although Plans 5 and 6 provide some degree of protection to the area, they will not contribute to the recreational use of the area. These plans are extremely costly and the minor benefits that they provide do not make up for the cost. Sand placement and periodic nourishment of the beach will not be as costly as Plans 5 and 6, and will protect the backshore area while also providing recreational benefits. Plans 5 and 6 are also more environmentally damaging than the sandfill plans. Plan 4 will help to retain a small area of the beach space. Plans 1, 2, 3 and 4 are viable alternatives, both structural and nonstructural, which were formulated to contribute to the study objectives of the area. These plans will be

compared and traded off against one another for NED and EQ benefits in the "Assessment and Evaluation of Detailed Plans" section to determine which plan best meets the needs and desires of the area.

CONCLUSIONS

Following the first stage screening of alternative measures for beach erosion, Plans 1, 2, 3 and 4 have been selected for further evaluation since they meet the requests of Federal, State, regional, and local interest groups for reducing the loss of valuable beach and improving the quality of the beach to meet the future demand for recreational bathing facilities. These plans meet one or more of the criteria of the problem and opportunity statements. These alternative plans will be carried forward for more detailed analysis.

ASSESSMENT AND EVALUATION OF DETAILED PLANS

This section contains an analysis of the four alternative plans of improvement selected for detailed study. Evaluation of the alternatives is based on their fulfillment of the project problem and opportunity statements.

The detailed plans of improvement considered for this final evaluation were developed using the preliminary design data recommended in the reconnaissance stage planning report, and any input received from concerned interests. These two parameters were first and foremost in developing plans that will support improved recreational use and efficient shore protection. The various improvement methods considered are groins, shore management guidelines, sandfill, and lowering of the landward end of the existing Federal groin structure. Each method has a distinct function, and the method or combination of methods that is most efficient and environmentally and economically acceptable will be selected. The proposed sandfill will prevent overtopping of the beach and provide protection to the eroding backshore and additional recreational beach area. A groin will provide additional protection to the beach from storm waves, limit littoral drift, and provide an effective sand retention measure. Lowering the existing Federal groin will allow wind-blown sand to reach and restore the deteriorating Compo Cove Beach. A nonstructural shore management plan will provide guidelines to assist the State in managing the backshore. These measure include such things as providing designated walkways onto the beach, placing sand fences along the backshore to trap wind blown sand, planting dune grass in the backshore dune areas to encourage new vegetation, and preventing beach bathers from using these areas. Other management measues could be restricting the number of beach users on peak days, limiting parking to four hours per day in order to encourage a greater turn over, and designating certain areas for fishing.

DESIGN CRITERIA

The proposed plans of improvement were designed to provide needed protection against wave action experienced during frequent winter storms and to provide and preserve a much-needed recreational bathing and park facility. The improvements would also provide substantial erosion control protection against rare severe storms and hurricanes. Pertinent design features are described below.

DESIGN TIDE

The design tide selected is 11.0 feet above mean low water (4.0 feet above mean high water). It is expected to occur with a frequency of about once in 2 years. The design tide elevation was selected as the maximum practical level that should be considered in constructing protection for the generally low backshore area. (See Appendix 4 for details.)

DESIGN WAVE

The design wave height, selected for the proposed improvement was determined in accordance with methods developed by the Coastal Engineering Research Center (CERC), Fort Belvoir, Virginia. Wave heights and directions were determined based on available wind and storm data and were corrected to allow for the effects of shoaling and diffraction. (See Appendix 4 for details.)

WAVE RUN UP

Wave run up on the proposed structures and sandfill was computed for a storm estimated to occur with a frequency of once in 2 years. An allowance was made for some erosion of the beach in selecting the wave height based upon past experience and conditions observed after storms. A 6 foot, 5 second wave would cause a wave run up to an elevation of about 1.5 feet above the design water surface or to 0.5 feet above the constructed beach berm elevation, based on an average beach slope of 1 vertical on 15 horizontal.

SANDFILL AND PERIODIC NOURISHMENT

The proposed project will require a substantial amount of sandfill to provide protection to the backshore and meet the recreational needs of the beach. The sandfill required will be clean and free of all pollutants. A portion of the sandfill could come from nearby Compo Cove. This material, if environmentally acceptable, could be used as a base or underlayer for the beach with the remaining top layer (4-6 feet) coming from a nearby land source. If this offshore material is either not available or not acceptable then a commercial source located within fifty miles of Sherwood Island would be used. Our investigation of source of beachfill material

indicates that necessary quantity and specified quality of material is available from local commercial sources.

As part of the cost of construction, annual periodic nourishment of the project is included as part of the cost of construction. This nourishment is necessary to maintain project dimensions and is based on available historic data of losses that have occurred in the area.

MITIGATION REQUIREMENTS

Mitigation measures would include steps to control the temporary noise, air, and water polution caused by placing the sandfill on this recreational beach and constructing the rock groin. Also, before construction, surveys should delineate the exposed areas of cobblestones, and care should be taken not to place excessive sand over these areas. Although this near-shore zone is not an active shellfish area, there is evidence of some clams, mussels, snails, and other marine life in this rocky and cobble stone environment. Every attempt will be made to minimize, the impact on this dynamic area. Any sandfill placed on the beach and in the intertidal zone would eventually be redistributed by the tides and would assume a natural slope. This uniformly graded material will minimize the on and offshore movement of material and will have no impact on offshore oyster beds. We feel that the impact in this area and seaward will be relatively insignificant. This is evident from historic surveys that show that very little change has taken place below mean low water over the years after the initial placement of sandfill in 1957. Other mitigation precautions to be taken are to assure the quality of the sandfill material and construct the beach in the fall or early spring with no construction beyond 30 June. No mitigation will be required with Plan 4.

GENERAL ASSESSMENT AND EVALUATION OF IMPACTS

The general impacts of the proposed project that are common to the three beach erosion control plans containing sandfill of improvement are evaluated below.

Sandfill Impacts - The impacts of the proposed sandfill on the beach are only short term and include temporary air, noise, and water pollution. The most serious impact is the temporary disruption of the bottom in the intertidal zone. To reduce this adverse impact the proposed sandfill material specified will be well sorted to reduce the amount of fine material, thereby reducing the turbidity caused by the placement of sandfill in the water. Other impacts, such as the sandfill placed in the intertidal zone covering the cobblestones and temporarily destroying any clams or organisms attached to the stones, will be kept to a minimum by

using a steeper foreshore slope. The 1 horizontal on 15 vertical slope will reduce the extent to which the toe of the sandfill extends into the water.

Dredging Impacts - Impacts caused by dredging the adjacent Compo Cove will only be short term and temporary in nature. This dredged material, if used, will be placed along the West Beach as an underlayer to be covered with a better quality material from a local land source. The material will be restricted to the backshore area of the beach with the better quality material being placed in the intertidal zone. This will minimize the turbidity and the littoral transport of the fine material caused by current and wave actions.

The amount of dredged material expected to be removed from the cove is approximately between 30,000 and 50,000 cubic yards.

Long-Term Impacts - Long-term impacts would only occur as a result of the low-profile groin structure. The construction of the low-profile groin structure will have an impact on marine life because of its location. This impact will be minimal and affect only the marine life directly beneath the structure.

Shoreline Impacts - Placing sandfill on the West Beach will provide additional dry beach space for beach bathers and protection to the backshore park from storm-driven waves. No adverse impacts except during construction are foreseen at West Beach or the adjacent shoreline.

Impacts on Beach Erosion and Use - At present, West Beach is eroding at a rate of about 4.0 feet per year. As a result, the backshore park and picnic area is being eroded and attendance is restricted to the western section of the beach. The present beach is also being overtopped and waves are breaking on backshore embankments causing serious erosion. The three plans that include sandfill will facilitate existing beach use.

Economic Impacts - The increased use of the park as a result of these plans will have economic impacts on the park. An increase in revenue for the State, in the form of entrance fees and concession use, and a possible increase in staff and patrol jobs will result from increased park use. First aid requirements could be reduced because the sandfill will cover the exposed cobblestones; therefore, the number of bathers being treated for cuts from the exposed cobblestones would decrease. The economic impact evaluation is based on beach usage and prevention of loss of land.

Benefits for the project have been calculated based on the assumption that when the beach is completed attendance will increase immediately.

Costs have been estimated using 1981 price levels and an interest rate of 7-3/8 percent. Detailed estimates of the cost of each plan of improvement are contained in Appendix 4.

To determine the most practical and economically feasible plan of improvement, a benefit-cost analysis has been developed using current price levels and interest rates. A comparison of the estimated annual costs and benefits is displayed in the appendices.

PLAN 1

PLAN DESCRIPTION

This plan consists of widening the existing beach to a level berm, width of 200, 225, or 250 feet, by the direct placement of suitable sandfill along approximately 1,800 feet of shorefront extending from the west side of Sherwood Point to the east side of the existing Federal groin structure. (See Plate 2-1.)

IMPACT ASSESSMENT

Sandfill Impacts - Plan 1 requires the placement of approximately 90,000 cubic yards of material from a nearby commercial sandpit. If between 30,000 and 50,000 cubic yards of this material was taken from Compo Cove and used as an underlayer, the impact on the borrow area and on West Beach would be short term. This deepening of the cove would benefit local boaters who visit the area. West Beach is considered a very dynamic area. Historic shoreline change maps reveal that the beach is constantly moving. They also show that beyond the mean low water line the configuration of the shore has not changed drastically over the years. Unconsolidated sand material is transported from east to west, evidenced by the large buildup of sand along the east side of the existing Federal groin structure located at the west end of the beach. This material, a portion of which is lost to the Long Island Sound system, has not seriously damaged or destroyed marine life in the area. Based on past historic data, a wave refraction analysis, and a knowledge of the littoral process, it was determined that alongshore losses will be drastically reduced with a better quality of sandfill. The selection of the fill to be placed on the beach will be based on the material found on the beach. Every attempt will be made to obtain fill that will be compatible with the size and color of the existing material. Also, to enable a more accurate determination of sand movement in and around the beach, a series of post construction surveys and monitoring is being scheduled. This will assist in determining the effects of a better quality of material on sand movement.

Shoreline Impacts - This plan will impact the shoreline. The erosion of the shoreline will continue. However, it will be slower, because a better quality material will be placed on the beach. The present shoreline configuration is a result of storm, wind, and wave action. Historically, the shoreline along West Beach extended seaward approximately 250 feet from its present location. This was a result of the placement of sandfill in 1957. At that time the shoreline was eroding

very rapidly, but the demand for public recreational beaches was not as great as it is today. As the shoreline eroded over the years much of the eroded beach material was transported into Long Island Sound and Compo Cove. This was determined because there is no evidence in historic surveys of any larger deposits of material directly in front of West Beach. The proposed material to be placed on the beach will extend seaward of the existing backshore, approximately 300 feet, to the mean high water line, provide much needed beach bathing space, and have an average beachfill depth of 8.0 feet. To maintain the shoreline at or near design dimension, annual periodic nourishment will be high.

Nearshore Impacts - The placement of sandfill in the nearshore area will have little or no significant impact on marine life in the area. Preliminary surveys by the State and discussions with the Westport Shellfish Officer revealed that the area contains a limited amount of marine life, with "no significant shellfish population." Marine life such as clams, mussels and snails; is sparsely scattered along the shore and can be found mostly at or below the mean low water line. Because of the dynamic nature of this area, sand moves in and out of the area depending upon the time of the year. The rocky shore fronting West Beach is exposed in the fall and winter and covered with up to a foot or more of sand during the summer.

The proposed sandfill will be placed along the backshore and the natural tidal action will distribute the fill material in the nearshore area. It is anticipated that the material being distributed through this natural process will stay within the limits of the existing groin structure. A minimal amount of additional sandfill will be distributed at or below the mean low water line during construction. The beach will erode naturally through normal tide and storm action. With a better quality of material (material with fewer fines), losses offshore and alongshore will be greatly reduced. The slope of the fill in this area will be determined by the natural tide and storm action and will conform to the natural slope of the area. Previous surveys have indicated that over the period of record 1955 to 1980, material lost from the beach has not been deposited in the offshore area directly in front of West Beach. Indications are that this material has been transported within the Long Island Sound system. The profiles also reveal that in the vicinity of the mean low waterline the amount of sand deposited is relatively unchanged. The proposed sandfill is designed to restrict the placed material within the existing mean low waterline. No material will be placed at Sherwood Point.

Economic Impacts - There are no significant adverse economic impacts as a result of the proposed beachfill. The impacts that result from the placing of suitable sandfill are mostly positive and any adverse impacts are short term. (See Table 1 for economic benefits.)

EVALUATION AND TRADE-OFF ANALYSIS

This plan will provide additional beach bathing space and protection to the eroding backshore. Storm-driven waves will no longer erode the backshore park area but will break seaward of the eroding embankment. The trade-off of this plan is that by constructing the project, additional benefits will be obtained through increased beach use and protection of the backshore park. The sandfill placed on this beach will provide protection to the backshore park and provide a recreational beach bathing area that is beneficial to State and local businesses. The benefits from this improvement far exceed the short term losses that would occur to the marine life along West Beach. According to the Westport Shellfish Officer, the clamming along West Beach is not significant, and is not considered a viable resource. This is a very dynamic area and the existing ground in the surf zone is constantly changing. Sand is deposited and removed from this area on a regular basis. At any one time 6 inches to 1 foot of sand could be deposited over the rocks and cobbles and remain there for several months. During the summer months, there have been times when the entire area has been covered by sand. The marine life now existing on the beach has survived such changes and it is not anticipated that the addition of any sandfill will create a hazard. Long term benefits derived at from this plan far outweigh the short term environmental losses.

PUBLIC VIEWS

The majority of the public views expressed to date have been favorable with respect to the construction of this improvement. For additional information, see Public Views and Responses Appendix.

PLAN 2

PLAN DESCRIPTION

This plan consists of widening the existing beach to a level berm width of 200, 225, or 250 feet, by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline between Sherwood Point and the existing Federal groin structure and lowering the landward end of the existing Federal groin structure. (See Plate 2-1.)

IMPACT ASSESSMENT

Sandfill Impacts - The impacts of this plan are the same as those of Plan 1, plus the lowering of the existing Federal groin at the west end of the study, which will allow some wind-blown sand to overtop the structure and nourish the down-drift beaches.

Shoreline Impacts - The impacts of this plan are the same as those of Plan 1.

Nearshore Impacts - The impacts of this plan on the nearshore will be the same as those of Plan 1.

Economic Impacts - This plan will have the same economic impacts as Plan 1. (See Table 1 for economic benefits.)

EVALUATION AND TRADE-OFF ANALYSIS

This plan will provide the same evaluation and trade-off features as Plan 1.

PUBLIC VIEWS

The majority of the public views expressed to date have been favorable with respect to the construction of this improvement. For additional information, see Public Views and Responses Appendix.

PLAN 3

PLAN DESCRIPTION

This plan consists of widening the existing beach to a level berm width of 200, 225, or 250 feet, by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline between Sherwood Island Point and the existing Federal groin structure, lowering the landward end of the existing Federal groin structure, and constructing one low-profile groin structure located approximately 900 feet west of Sherwood Point. (See Plate 2-1.)

IMPACT ASSESSMENT

Sandfill Impacts - The impacts of this plan are the same as those of Plan 1.

Shoreline Impacts - This plan will not have any significant adverse impact on the shoreline. It is designed to stabilize the backshore by compartmentalizing the sandfill. The low-profile groin structure will attract marine species and encourage fishing during the early spring and winter months. The groin (as discussed in Appendix 4) will not interrupt the normal alongshore or offshore movement of material. These normal losses were taken into account and an annual beach nourishment program is recommended.

Nearshore Impacts - The impacts of the placement of sandfill in this plan are the same as those of Plan 1. The placement of the low-profile groin structure will destroy some of the nearshore marine life, however, the groin itself will attract other marine life to offset this loss. The impact of covering the clams is not significant because the area to be covered is relatively small. The impact of constructing the groin will also be beneficial to local fishermen that frequent the area.

Economic Impacts - This plan will have the same economic impacts as Plan 1. In addition this plan will provide fishing benefits due to the construction of the low-profile groin structure. (See Table 1 for economic benefits.)

EVALUATION AND TRADE-OFF ANALYSIS

This plan will have the same evaluation and trade-offs as Plan 1. The additional low-profile groin will compartmentalize the sandfill and also provide a fishing facility for sport fishermen that will outweigh any adverse impacts due to its construction. According to park officials, fishing at Sherwood Island is becoming increasingly popular, where as there is very little clamming along the shoreline.

PUBLIC VIEWS

The majority of the public views expressed to date have been favorable with respect to the construction of this improvement. For additional information, see Public Views and Responses Appendix.

PLAN 4

PLAN DESCRIPTION

This plan gives guidelines for managing the use of the backshore and provides additional guidance to the State for future public participation in water related activities. These activities include restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dune. These activities will help the dunes to grow and help to stabilize the backshore area. The dunes will supply additional nourishment to the beach.

IMPACT ASSESSMENT

Offshore Impacts - There will be no additional impacts on the offshore area with this plan. The offshore will be allowed to erode as it is presently. Any possible effects on the oyster beds as a result of this plan are presently occurring, and these effects will not be increased in any way as a result of this plan.

Shoreline Impacts - There will be no additional impacts as a result of this plan. The shoreline will continue to erode naturally at its present rate, which will not only impact the West Beach but also the offshore and adjacent areas.

Nearshore Impacts - There will be no new impacts on the nearshore as a result of this plan. The material that is eroding will continue to be distributed along the nearshore and could impact the marine life in that area, although not significantly.

Economic Impacts - This plan will allow the beach to continue to erode naturally, resulting in the loss of land and a slight decrease in the attendance. This decrease in attendance will not relieve the economic pressure for useable dry beach space. However, the grass planting and other management guidelines will help in the growth of the dunes. The dunes will provide additional nourishment to the beach which will help to slow down the rate of erosion. This slower rate of erosion will eventually cause the beach area at the western end of West Beach to reach a point of equilibrium. Although this point of equilibrium will not supply the beach space necessary, it will give a little more additional space than there would be if no Federal action were taken. (See Table 1 for economic benefits.)

EVALUATION AND TRADE-OFF ANALYSIS

The evaluation of this plan is limited to preservation of a 900-foot section of backshore beach located adjacent to the existing Federal groin structure. The plan will trap wind-blown sand and, by controlling the access to the beach, allow new beach grass to grow and develop a backshore dune. The dune will provide additional nourishment to the beach, which will help to stabilize a small beach area. The trade-off would involve the preservation of the backshore beach adjacent to the existing Federal groin structure by preventing beach use in this area and encouraging dune restoration. Although this useable beach bathing space would be lost, this backshore area will provide a dune that will help to stabilize a small beach area.

PUBLIC VIEWS

Public views expressed to date on this plan have been unfavorable. This is mainly due to the fact that the much needed dry beach space will not be provided by this plan.

IMPLEMENTATION RESPONSIBILITIES

Cost Allocation - One hundred percent of the cost of the project is allocated to the beach erosion control improvements. There are no other components in the Federal project beyond sandfill and groin construction.

Cost Apportionment - The Federal Government is responsible for 100 percent of the study cost and 70 percent of the first cost of construction, including final plans and specifications and 70 percent of all future nourishment as required. Groin structure maintenance is a non-Federal responsibility. The Federal cost including beach nourishment cannot exceed $1,000,000 under the Section 103 program.

Non-Federal Responsibilities - This recommended Federal beach erosion control study with Federal participation is subject to the conditions of

non-Federal local cooperation as shown in the recommendations at the end of this section.

COMPARISON OF DETAILED PLANS

The demand for recreational beach bathing space during summer months at Sherwood Island State Park has fluctuated over the years. As the dry beach space decreased due to erosion of the beach, attendance decreased. At this writing, the erosion of West Beach (see Plate 1-10) is becoming even more serious. Due to this condition, four alternative plans of beach erosion control improvements will be compared to the base condition. The first three plans have one thing in common; they all require the placement of suitable sandfill that will supply the much needed dry beach space to satisfy the ever growing demand at Sherwood Island State Park. The last plan has no major recreational use benefits.

Plans 1, 2, and 3 - These three plans require the placement of suitable sandfill to enhance the recreational use of West Beach. Plan 3 is the only plan that utilizes an intermediate low-profile groin designed to compartmentalize the placed sandfill. The groin will not interrupt the natural process of alongshore movement of material that nourishes the down-drift beaches. Plans 1 and 2 do not contain the low-profile groin structure, therefore, losses due to normal erosion will be high. Although these plans both provide for sufficient beach use after construction and satisfy the problem and opportunity statements, maintaining project alignment would be necessary. Plan 3 combines all of the positive factors of Plans 1 and 2. It further provides for continuing healthful recreational beach use with only minimum periodic nourishment requirements. This plan satisfies the planning objectives and benefit-cost requirements, and complies with the planning constraints.

Plan 4 - This plan was developed as a shoreline management plan to provide backshore protection to the western end of West Beach. This plan will enable wind blown sand to be collected by the sand fences to later serve as a source of sand for the beach during frequent storms. By controlling the access to the beach, the dune will continue to grow and eventually become stable. Beach attendance on West Beach will decrease due to erosion until the point of equilibrium is eventually reached. The continued regrading of the sand annually will provide a useable dry beach bathing area in front of the dunes. This new dry beach area will determine the maximum acceptable beach use of this section of Sherwood Island State Park Beach. The benefits from this plan are not sufficient to justify the construction cost. This plan also fails to conform the requirements of the "problem and opportunity statements."

COMPARISON OF DETAILED PLANS

Table 1 compares the four considered plans of improvement in detail. In developing this table, the costs and benefits are based on current 1981 price levels. An interest rate of 7-3/8 percent was used over the 50-year period of analysis.

Environmental Comparison - In evaluating and comparing the environmental impacts of the four alternative beach erosion control plans, the natural process and the preservation of the shoreline, offshore areas and adjacent private shore were prime considerations. Plan 1 consists of the direct placement of suitable sandfill, and Plan 2 is the same as Plan 1 plus the lowering of the inner end of the existing Federal groin structure. These plans would impact the nearshore and shoreline of the proposed West Beach. The plans do not provide for a structure to reduce alongshore losses, therefore, sand losses as a result of these plans will be excessive and would impact the nearshore and shoreline areas. The lowering of the groin would allow wind blown sand to nourish the downdrift shore. These plans with their excessive losses would impact the nearshore and backshore areas. Plan 3, although similar to Plans 1 and 2, has an additional low-profile groin structure to compartmentalize the sandfill and reduce losses. The structure will impact a small part of the nearshore area by permanently covering marine life under it. This area is relatively small, and the covering of the existing marine life will be offset by new species being attracted to the new structure. The construction of the structure will reduce the alongshore losses and reduce the impact on the shoreline and nearshore areas.

Care and consideration will be given to all marine life during construction. This will be done by placing a better quality of sandfill, containing fewer fine materials, on the beach, which will reduce losses from above normal wave action and will result in less marine life being covered by sediments. During construction the rocky area fronting the beach will be carefully delineated and care will be taken to minimize the impact of placing sandfill in the nearshore area.

Plan 4 would have the least detrimental impact on the environment. It provides primarily a nonstructural improvement and management measures to retard the erosion of the western section of the beach. This plan does not recommend any artificial improvement that could impact on the environment.

Comparison Summary - Table 2, titled "Summary Comparison of Alternative Plans," is a general evaluation of considered plans of improvement and includes "base condition" or present conditions, and "without project" or if no Federal work is done. The table represents an overview of the determining factors in selecting the options of improvement for West Beach. This is accomplished by displaying the significant beneficial and adverse impacts. This system is used as a method for accurately evaluating the analysis of a final decision.

TABLE 1

BENEFITS AND COSTS FOR CONSIDERED PLANS

PLAN	BERM WIDTH	TOTAL FIRST COST	SHERWOOD ISLAND 70/30 COST SHARING				ANNUAL BENEFITS	ANNUAL COST	B/C RATIO	NET BENEFITS
			$ COST SHARING		$ ANNUAL COST					
			FEDERAL	NON-FED	FEDERAL	NON-FED				
1	200	833,000	583,000	250,000	72,000	31,000	718,600	103,000	6.98	615,600
	225	947,000	663,000	284,000	118,000	50,500	788,600	168,500	4.68	620,100
	250	1,098,000	768,500	329,500	188,000	80,500	888,600	268,500	3.31	620,100
2	200	838,000	586,500	251,500	72,500	31,000	725,800	103,500	7.01	622,300
	225	952,000	666,500	285,500	118,000	51,000	796,500	169,000	4.71	627,500
	250	1,103,500	772,500	331,000	188,500	80,500	897,500	269,000	3.34	628,500
3	200	960,000	672,000	288,000	65,800	29,200	734,800	95,000	7.73	639,800
	225	1,092,500	765,000	327,500	104,000	49,000	805,500	153,000	5.26	652,500
	250	1,257,000	880,000	377,000	157,000	79,000	906,500	236,000	3.84	670,500
4	N/A	76,500	53,500	23,000	7,500	3,200	4,000	10,700	.37	0

RATIONALE FOR DESIGNATION OF NED AND EQ PLANS

Plan 3 of the four alternative plans is the plan that maximizes the net economic benefits; therefore, it has been selected as the NED plan. Plan 3 has three optional level beach berm widths. The last plan or the plan with the 250-foot level berm width, is the most economically satisfactory. The plan is optimized when the benefits of the total output of each plan equals the economic costs of the plan.

Plan 4 of the four plans would help to slow down the erosion rate of the western portion of the West Beach without creating any detrimental environmental impacts. Since this slowing of the erosion would help to preserve the environmental stability of this area, this plan is selected as the EQ Plan.

RATIONALE FOR SELECTED PLAN

Plan 3, with a 200-foot level beach berm, is selected for implementation. It provides significant net benefits, gives the maximum B/C ratio, and the environmental impacts are not significantly greater than those of Plans 1 and 2. Plan 3 will have a slightly greater impact on the nearshore because of the additional groin, but will reduce alongshore losses substantially by compartmentalizing the sandfill. Plans 1 and 2 have no provisions for preventing these alongshore losses, therefore, the periodic nourishment necessary to maintain shoreline alignment will be significantly higher. Although Plan 4 will stabilize a small section of the beach, it does not meet the present or future economic needs of the park.

CONCLUSIONS

The proposed project has been reviewed and evaluated with the overall public interest in mind. This review included an evaluation of all pertinent data concerning the proposed plan of improvement as well as the stated views of other interested agencies and the concerned public, relative to the various alternatives in considering a beach erosion control improvement along West Beach of Sherwood Island State Park, Westport, Connecticut.

The possible impacts of the proposed alternatives have been studied according to engineering feasibility, the environment, and economic factors as they relate to the regional, and national resource development and other social effects as they relate to the public interest. The details of these issues have been stated in the formulation of the plan of improvement and can be found in other sections of this report.

In summary, substantial benefits are to be derived by providing a recreational beach erosion control improvement at West Beach.

TABLE 2
SUMMARY COMPARISON OF ALTERNATIVE P
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 1
A. Plan Description			
1. Major Features	Base Condition	No Action	*
2. Land Requirements			
a. Recreational Area	200 acres	Continuing loss of land	200 acres
b. Temporary	N/A	N/A	N/A
c. Permanent	N/A	N/A	N/A
3. Existing Conditions			
a. Level Beach Berm	100 ft.	Continuing erosion	N/A
b. Beach Width Above MHW	100 ft.	Continuing erosion	N/A
c. Park Facilities	yes	yes	yes
d. Ownership	state	state	state
(1) Federal	N/A	N/A	N/A
e. Additional Land Requirements	N/A	N/A	None
f. Structures			
(1) Federal			
(a) Seawall	no	no	no
(b) Groins	1	1	N/A
(c) Jetty	no	no	N/A
(2) Non-Federal	N/A	N/A	N/A

TABLE 2
[illegible]PARISON OF ALTERNATIVE PLANS
[illegible]OOD ISLAND STATE PARK
[illegible]ESTPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
*	*	*	*
200 acres	200 acres	200 acres	200 acres
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
yes	yes	yes	yes
state	state	state	state
N/A	N/A	N/A	N/A
None	None	None	None
no	no	no	no
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

*see Table 2 System of Accounts
for description of plans

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TABLE 2
SUMMARY COMPARISON OF ALTERNATIVE PL
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 1
4. Considered Plans			
a. Dry Beach Width Above MHW			
1. 200 ft. Level Beach Berm	N/A	N/A	275 ft.
2. 225 ft. Level Beach Berm	N/A	N/A	300 ft.
3. 250 ft. Level Beach Berm	N/A	N/A	325 ft.
4. Non-structural	N/A	N/A	N/A
b. Structures	N/A	N/A	None
c. Revetments	N/A	N/A	no
B. Impact Assessment			
1. National Economic Development			
a. 200 ft. Level Beach Berm	N/A	N/A	
1. Total Annual Benefits	"	"	$718,600
2. Total Annual Costs	"	"	$103,000
3. B/C Ratio	"	"	6,98
4. Net Benefits	"	"	$615,600
b. 225 ft. Level Beach Berm	N/A	N/A	
1. Total Annual Benefits	"	"	$788,600
2. Total Annual Costs	"	"	$168,500
3. B/C Ratio	"	"	4.68
4. Net Benefits	"	"	$620,100

TABLE 2
ARISON OF ALTERNATIVE PLANS
OD ISLAND STATE PARK
TPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
275 ft.	275 ft.	275 ft.	N/A
300 ft.	300 ft.	300 ft.	N/A
325 ft.	325 ft.	325 ft.	N/A
N/A	N/A	N/A	200 ft.
None	*	*.1	N/A
no	no	no	no
$718,600	$725,800	$734,800	N/A
$103,000	$103,500	$ 95,000	N/A
6,98	7.01	7.73	N/A
$615,600	$622,300	$639,800	N/A
$788,600	$796,500	$805,500	N/A
$168,500	$169,000	$153,000	N/A
4.68	4.71	5.26	N/A
$620,100	$627,500	$652,500	N/A

* see Table 2 System of Accounts
for description of plans

2

TABLE 2
SUMMARY COMPARISON OF ALTERNATIVE P
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 1
c. 250 ft. Level Beach Berm	N/A	N/A	
1. Total Annual Benefits	"	"	$888,600
2. Total Annual Costs	"	"	$268,500
3. B/C Ratio	"	"	3.31
4. Net Benefits	"	"	$620,100
d. Non-structural	"	"	N/A
2. Environmental Quality			
a. Air Quality			Moderate increase in c
b. Archaelogical Properties			none
c. Biological Resources			Disruption of aquatic
d. Water Quality			Temporary increase in
e. Noise			Temporary increase in
f. Aesthetic Values			Will be improved thro
3. Social Well-Being	N/A	N/A	Temporary disruption recreational opportu
4. Regional Development	N/A	N/A	Reduce deficiency of region. Increased c
C. Plan Evaluation			
1. Conforms to Planning Constraints and Concerns			
a. Avoid Adverse Effects on Nearshore - Fishing and Shellfish Area		-	yes
b. Avoid Adverse Effects on Adjacent - Shore Configurations		-	yes
c. Plans that are Formulated Should not-put Unreasonable Financial Burdens on the State		-	no

TABLE 2
ARISON OF ALTERNATIVE PLANS
)D ISLAND STATE PARK
TPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
			N/A
$888,600	$897,500	$906,500	N/A
$268.500	$269,000	$236,000	N/A
3.31	3.34	3.84	N/A
$620,100	$628,500	$670,500	N/A
N/A	N/A	N/A	$4,000
Moderate increase in dust levels during construction.			
none	none	none	none
Disruption of aquatic ecosystem - destruction of benthic organisms by filling.			
Temporary increase in turbidity during fill and construction phases.			
Temporary increase in noise levels due to construction.			
Will be improved through project construction.			
Temporary disruption of usual activity by construction activities. Increased beach recreational opportunities Reduce deficiency of salt water recreational facilities in this metropolitan planning region. Increased commercial activities. local businesses, and revitalizing old businesses			
yes	yes	yes	yes
yes	yes	yes	yes
no	no	no	no

2

TABLE 2
SUMMARY COMPARISON CF ALTERNATIVE P
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNT	BASE CONDITION	WITHOUT PROJECT	PLAN 1
2. Achieves Planning Objectives and Goals			
a. Provides a Safe Recreational Beach Facility	no	no	yes
b. Contributes to the Economic Strength and Well-Being of the Area	no	no	yes
c. Preserves the Environmental Quality of the Area	yes	yes	yes
d. Contributes to the Stability of the Beach	no	no	yes
D. Public Response			
1. Plan Found Acceptable	no	no	no
E. Implementation Responsibility	0	0	Plans 1 thru. 3, Plans 4 B/

TABLE 2
COMPARISON CF ALTERNATIVE PLANS
IERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
yes	yes	yes	no
yes	yes	yes	no
yes	yes	yes	yes
yes	yes	yes	no
no	no	yes	no

Plans 1 thru. 3, 70% Fedral Share and 30% Local Share
Plans 4 B/C Less than 1.0

2

Table 2, Summary Comparison of Alternative Plans, is an overall general analysis relative to the plan selected. It presents the determining factors that underlie each final alternative plan by displaying the significant beneficial and adverse impacts. This table is utilized for the purpose of trade-off analysis and final decision making.

It should be noted that the proposed improvement would temporarily disrupt the environment during construction. However, these impacts are not considered significant and this is stated in the Environmental Assessment and the Environmental Impact Statement. The most insignificant known impact that would result if the plan is implemented was considered in our determination; but due to the significant recreational benefits attributed to this popular beach, it is concluded that the adverse environmental effects would be more than offset by the improvement in the overall economic growth of the region.

The proposed action, as developed in this report, is based on a thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives. Any adverse effects or impacts on the environment and adjacent shores as a result of the proposed improvement were evaluated based on current available information. Whenever adverse effects were found as a result of a proposed plan, the plan was either abandoned or evaluated based on its merit in achieving the specified objective. The recommended action is consistent with national and regional policies, statutes, and administrative directives, and should best serve the intended use and interests of the general public.

RECOMMENDED PLAN

The recommended plan of improvement for West Beach, Sherwood Island State Park is Plan 3 with a 200 foot berm. It consist of beach widening by the direct placement of a suitable sandfill along approximately 1,800 feet of shorefront providing a 200-foot level beach berm at elevation 12.0 feet mean low water and a 275-foot wide dry beach berm above the mean high waterline. Also included is the construction of one low profile rock groin structure located approximately 900 feet west of Sherwood Point, designed to compartmentalize the sandfill; and the lowering of the inner end of the existing Federal groin structure to elevation 13.0 feet above mean low water. This plan will provide the needed backshore protection and dry beach space to satisfy the demand.

ENVIRONMENTAL ASSESSMENT

Small Beach Erosion Control Project
Sherwood Island State Park
West Beach
Westport, Connecticut

Prepared By
Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

July 1981

I. Introduction.

Although it is sheltered from the direct influence of the Atlantic Ocean by Long Island, Connecticut's coast is still subject to climatic and oceanographic forces which can produce substantial physical changes in the shoreline. Tides, currents, winds, and waves continuously alter the coastline. Their impacts are most pronounced following storm and hurricane events. At Sherwood Island State Park erosion resulting from these dynamic processes threatens a valuable public recreation beach. This report will detail the proposed plans, of the cooperating Federal, State, and local governments, to protect these crucial resources from further damages due to flooding and erosion.

II. Description of the Project Area.

Connecticut's coastline forms the northern shore of Long Island Sound, an elongated, estuarine embayment extending west-southwest to east-northeast for 110 miles between New York City and Westerly, Rhode Island. The shoreline can be geologically classified as a submerging coast of glacial deposition. Land composed primarily of glacial deposits, termed drift, is slowly being inundated by the rising sea at a rate of 0.3 feet per hundred years. The current coastal configuration represents an overall sea level increase of 33 feet in the past 7000 years.

Present-day coastal land forms are the result of glaciation, erosion of the pre-glacial landscape, and associated re-deposition of glacially eroded materials. The glacial deposits, called till, compose most of the State's coastal headlands, although some outcropping of bedrock can be found. Erosion with accompanying deposition of sediment from the more easily eroded drift deposits is the major natural source of beach sand.

The town of Westport, wherein the affected properties lie, is located on the western section of the Connecticut coast, approximately 50 miles east from New York City, in Fairfield County. The protected area encompasses 1,800 feet of beachfront extending from Sherwood Point to an existing impermeable rock groin at the western end of the park. The area is predominately a narrow barrier beach composed of coarse sands, gravel and cobble.

1. History of Sherwood Island State Park.

a. General. The Sherwood Island area of Westport has a rich history dating back to colonial times. The island itself was named for the famed Sherwood Forest in England when Alice and Thomas Sherwood emigrated to America from their home there approximately 300 years ago. A tide mill was erected in this historic area around 1705. Until it burned in 1896 it provided power to grind kiln-dried corn prior to its shipment to the West Indies.

Sherwood Island State Park has the distinction of being the first park ever acquired by the State Parks and Forest Commission. In 1914, the State purchased five acres of land with some shore frontage on Alvord Beach (presently East Beach) for possible use as a Federal hydroplane station. This plan was abandoned, however, and the State continued to purchase parcels of land on the island to consolidate its holding funded, in part, by a special appropriation of $5,000 from the general assembly in 1917. In the 1930's, the Elwood Farm and some twenty private residences in the central portion of the island were acquired and demolished, expanding the park and allowing additional access to the beaches. A lack of facilities and parking space and the difficulty of negotiating the ford across present-day Burial Hill Creek, limited the utilization of the park during these early years.

b. State Park Beaches. Man's activities in this area have substantially modified the environment of the beaches in the project area. The shoreline flanking Sherwood Point to both the east and west originally consisted of narrow barrier beaches of mixed sand and gravel. Within the tidal range, the beaches consisted entirely of shingles and cobbles, but beyond low water the bottom was fine sand.

Man's first activity in this area was a proposed Federal beach enrichment and protection project, resulting from an Army Corps of Engineers' Beach Erosion Control Report in 1949. It consisted of (1) artificial placement of sand along the entire shore of the park to create a beach 150' wide at mean high water, widened to 250' at Sherwood Point, (2) construction of an impermeable 500' rubble groin at the west limit of the park and (3) construction of 2 sheet steel and timber training walls, 400' and 500' long, to stabilize the creek at the east end of the park. The widening at the point would act as a stockpile to feed the beach areas to the east and west and the groin and training walls would catch and hold littoral drift material. This plan of improvement was implemented; the groin was built in October 1956, the training walls in February 1957, and the sandfill was placed the following June by hydraulic dredge from a borrow area 1,000 feet offshore of the point.

The results of this nourishment project can be ascertained by a comparison of shoreline configurations from before and after the action. The mean high and low water lines were surveyed in 1955 and again in 1957 by Clarence Blain Associates. Prior to construction in 1955, the average beach width of West Beach was 20 feet throughout. In 1957, it had increased to 150 feet at the western extremity and 230 feet at the eastern end.

Between 1957 and 1971 erosion was occurring reducing the size of the stockpile at the point and substantially lowering beach elevation throughout the State park. This phenomenon can be examined by exploring the shoreline changes revealed in the newer high and low water line survey conducted by the Army Corps of Engineers in 1971. The major losses of material between 1957 and 1971 occurred between mean high and low water

lines. At West Beach in 1971, the beach width was 260 feet at the west end and 180 feet at the east end, reflecting severe erosion of eastern portions and accretion in western portions behind the groin.

In November 1974, the Army Corps published a detailed report finding the existing beach had been overtopped during frequent severe storms and that beach elevation had been substantially lowered along a major portion of the shorefront. The beach conditions, detailed in the study, revealed that sand beach existed only above high water at the eastern and western extremities of the park. Below high water was a mixture of fine sand, cobble, stones and pebbles. Toward the point, the beach was very rocky throughout.

In 1975 a project was proposed by the State which involved a 250 foot extension to Sherwood Point, using 23,500 cubic yards of armor stone carefully placed to form a stable revetment-type structure to protect the point from severe erosion which was threatening the septic fields fronting the pavilion. The existing westerly groin would be raised 9 feet by the placement of 11,500 cubic yards of stone and tied into the dune to the rear, which was proposed to be restored, work was initiated during the winter of 1975, but construction was halted early in 1976. Approximately 90% of the point revetment was completed and 40% of the material comprising the raising of the west groin was in place when construction was halted.

The effects within the State park of the 1975 modification can be discovered through a comparison of the 1971 survey with a subsequent survey completed in 1979 by Flaherty and Giavara. The survey showed that West Beach is subject to erosion and deposition which has been accelerated by the amoring of the point and the raising of the groin. Near the point, the mean high water and low water lines have retreated 100 feet and 50 feet respectively since 1971. This erosion is accompanied by increased accretion in the western portion of the beach.

c. State Park - West Beach. The West Beach of Sherwood Island State Park extends west-northwesterly in a slightly curved conformation, for roughly 2,400 feet from Sherwood Point to the terminal groin. The eastern portion is backed by a scarp of till which is grassed over and forms the margin of the park's picnic area. The much wider, western sector is backed by sand dunes of medium to coarse sand, which were restored as part of the 1976 park improvements.

The two portions of the beach are subject to vastly different dynamic conditions as a result of beach orientation and the effects of the terminal structures at either end. The eastern section is subject to severe erosion because the direction of wave attack normally results in a rapid transport of beach material from east to west and the re-armored point cuts off sources of sediment on adjacent eastward beaches. The western section is an area dominated by accretion as the terminal groin impounds this westward moving sand.

The present configuration of the western terminal groin is the result of both its initial construction in 1956 and the partially completed alterations of 1976. This 500 foot long impermeable rubble groin was initially built to an elevation of 12 feet above mean low water at the landward end, sloping to 4.5 feet above mean low water at the seaward end. The 1976 project to raise the groin 9 feet was halted before completion with only the section above mean low water being elevated. The height of this inboard section presently varies from 15 to 17 feet.

The eastern half of the beach itself has a very narrow backshore composed of medium sand and cobbles. The upper foreshore of this section is predominately gravel and cobbles and slopes toward low water at an average gradient of 1:20. The flat lower foreshore is almost completely covered by cobbles with only minor areas of fine sand.

In contrast, the western half of this beach is generally composed of sand throughout. Medium to coarse sand compose the wide backshore and upper foreshore, which has gentle slopes averaging 1:20. The flat lower foreshore consists mainly of fine sand.

d. Flora and Fauna. As is the case with most dynamic sandy beach environments, resident flora and fauna are extremely rare on the foreshore and backshore areas of the beach. The physical stresses of breaking waves, shifting sands and rising and falling tides, along with the extremes of heat and desiccation from the sun at low tide to the inundation of saline water at high tide, and other variable factors make these beaches an inhospitable environment. The eastern end of this beach, being quite rocky could provide a habitat for those types of mollusks which can attach to the rocky substrate and survive the extreme rigors of the environment. Prominent examples being the periwinkles and mussels.

There have been no studies previously performed to document the floral and faunal species which inhabitat this specific region of Long Island Sound. What follows is a brief description of the general types of organisms likely to be present in the immediate offshore area.

Various species of shellfish are common to this area of Long Island Sound. The different varieties are most usually found associated with their particular preferred habitat. Eastern oysters (Crassostrea virginica) and blue mussels (Mytilus edulis) require a solid substrate for anchorage and are found in the rocky portions of the project area. Hard-shell clams (Mercenaria mercenaria) are buried near the surface in sandy or muddy bottoms of quiet areas. Soft-shell clams (Mya arenaria) are buried deeper in muddy bottoms. Oyster drills and whelks prey upon other species of mollusks. Other species that may be found scattered throughout the area include razor clams, barnacles and chitons. The project area is not an important breeding ground for any finfish species, nor do anadromous fish make any spawning runs in the area.

None of the species in the project area are considered to be rare or endangered. In fact, they are commonly found in similar habitats throughout Long Island Sound. Nor are they present in sufficient numbers within the cove to make commercial utilization feasible. For example, the leased shellfish beds do not extend into the cove. The rocky substrate required by the eastern oyster exists in only widely scattered portions of the cove, near shore.

e. Recreational Environment. Sherwood Island State Park is the major saltwater swimming facility on the western end of Long Island Sound. The parks receive heavy recreational use due to its location in the highly populated Fairfield County, just 50 miles east of New York City.

The park encompasses 200 acres and presently has parking spaces for approximately 5,000 cars. Northwest of West Beach is a large picnic grove. This 6 acre wooded picnicking area, containing mostly oaks and hickories, has scores of tables and fireplaces. To the west of this grove are a first aid station and bath houses.

f. Physical Environment.

1. Wind and Waves - Wave analyses of the project area have been performed by both Flaherty and Giavara and the Army Corps of Engineers. By using inputs of data on prevailing wind directions and speeds and fetch distances, the height direction and effects of storm produced waves can be calculated.

The study area has significant exposure to wave approaching from the east through southwest. Easterly approaching storm waves produce strong westward littoral movement on the State park beaches, particularly from the point and along West Beach. With a southeast direction of approach, the resulting littoral transport is still quite strongly westward along West Beach and the point.

2. Tides and Currents - The normal tidal range within the project area is 7.0 feet above mean low water; the spring tidal range is 8.0 feet. An ordinary storm event, occurring with a frequency of slightly more than once a year, produces a storm surge of 10.0 feet above mean low water. Either a hurricane or a slow moving, easterly storm, that stalls off the east entrance of the Sound, can produce a storm surge several feet higher than this on infrequent occasions. The highest tide on record was experienced during the hurricane of September 1938, which generated a storm surge of 13.7 feet above mean low water.

Off Sherwood Point, there is a strong westward-directed current with speeds of 0.7 to 1.0 feet per second during flood portion of the tidal cycle. The current is not strong enough to initiate motion of bottom sand, but it is capable of transporting sand which has been placed into suspension by waves.

III. Need for Action.

Presently West Beach is undergoing an average loss of four feet per year of landward retreat which is limiting the recreational use of the beach. This is especially true of the eastern section of West Beach where rocky conditions preclude safe swimming in that area.

Control of beach erosion and reversal of the losses and damage sustained by West Beach of Sherwood Island State Park will involve two types of action. First, approximately 90,000 c.y. of fill material will be placed along West Beach. The underlayer of sand may be dredged from Compo Cove. This sediment is composed of naturally occuring sands which will be analyzed by the State of Connecticut. If this sediment is found to be compatiable it will be used in conjunction with a suitable commercial land source which will form a 6 ft. layer above the material from Compo Cove. If the material from Compo Cove is found unsuitable then all the needed sandfill will be obtained from a clean commercial land source.

The project also calls for the landward end of the existing Federal groin, located at the western limit of the proposed improvement area, be lowered to allow wind blown sand to move along the beach. An additional low profile groin will be constructed between the west limit of the study and Sherwood Point. The materials for the groin will be clean and obtained from a nearby commercial land source.

IV. Environmental Impacts.

The project as proposed will have only minimal temporary impacts to the local aquatic environment. No significant or persistent adverse impacts are expected for several reasons.

a. Fill Material. The fill material will be clean, free of any harmful contaminants and composed of naturally occurring sands from Compo Cove, and/or material obtained form a suitable nearby commercial land source. The material from Compo Cove will be used as an underlayer for West Beach only after it is analyzed by the State of Connecticut and determined to be clean and of a compatible grain size to the existing sediment on the beach. A clean commercial land site will also be needed to either supply the entire fill material or enough to construct a 6 foot layer above the material from Compo Cove. The commercial material will be of compatible grain size, color and free of all harmful contaminants.

b. General Construction. During the five months of West Beach rebuilding activity, construction noise will disturb the beach and surrounding areas, recreational use of the beach will be impeded, some equipment related air emissions will occur and energy will be consumed in operating the equipment. Changes in the project area will include the loss of some areas of hard bottom, both intertidal and subtidal which may be inhabited by oysters and mussels.

Noise will be generated by both the dredging equipment and trucks transporting sand. Mechanical dredging would produce more noise than hydraulics. Depending on the source of fill, trucks may be transporting cove-derived sand or fill from outside sources. In either case, the use of trucks is necessary. However, as not all beach segments will be worked on simultaneously the maximum noise level experienced at any one receptor location will not be continuous nor will it last the entire five month construction period. All construction noise will terminate with the project's completion.

Recreational use of the beach will be hindered during the construction period. Access along the beach will be reduced by the presence and operation of heavy equipment and by a non-continuous beach surface. The scheduling of the project for late winter and early spring will reduce the importance of these impacts. As with other construction impacts, this one will terminate when construction is complete.

Emission of air pollutants attributable to this project will be both insignificant and temporary. In addition, were the project not to take place, much of the equipment used would be employed elsewhere. Therefore, the emission impacts would not be negated.

Energy consumed in the project will also be a temporary impact. Although the amount of fuel consumed by the truck and dredge is large, it will not represent any strain on local fuel supplies nor cause any price or demand aberrations in the area.

One final project cost will be the destruction of both hard-shell and soft-shell clams living in the potential borrow area. A biological survey of the borrow pile found both varieties of clams to be present in insignificant numbers. These species are not uncommon and are found on adjacent tracts.

c. Impacts of Groin Construction. Disturbance of the beach environment as it affects both passive and active recreational pursuits is the most obvious result of the construction activity. Use of the beach is effectively denied during the period of the placement of fill and erection of the groins. Scheduling of work for late winter and early spring will minimize but not eliminate these conflicts.

As a temporary construction impact unavoidably inherent in the placing of the groin stones on the sandy bottom material, certain amounts of bottom material will be disturbed and suspended in the building of the groin. This material should settle out rapidly after each individual placement.

Immobile organisms may be buried or suffocated if a sufficient thickness of sediment is deposited from suspension. The survival of oyster and clam larvae can also be affected by siltation. A late winter time frame for implementation will avoid the larval period for local

shellfish. Impacts on the adult population will be minimal due to the location of the groins outside of the oyster bed areas and the small travel distance of suspended sediments.

Certain results of the presence of the groins are long term impacts. The conversion of the areas upon which the groins rest from soft bottom to hard bottom is such a result. Burrowing species will lose this amount of area while benthic organisms will gain a much larger amount of surface area due to the irregular surfaces of the groins. The new hardrock surfaces created by the groins both in the intertidal and subtidal zones will compensate for similar habitat covered by the sandfill placement for the pocket beach.

Increased access for fishermen will be another long term impact of a groin construction. This will accure chiefly through the West Beach groin because of private ownership. By Corps estimates, a minimum of 2,500 fisherman/day of annual use can be expected.

Access along the beach will not be impaired by the groins. The groin will be tied into the beach berm elevation at its inboard end to provide for an uninterrupted profile to enhance both appearance and access.

d. Impacts of Dredging. The dredging of Compo Cove, if this option is used, will provide a portion of the sandfill to be used for beach nourishment will result in both short and long term impacts to the environment. Temporary impacts include increased turbidity in the waters in the vicinity of the active dredging operation, which will affect the water chemistry and neighboring flora and fauna. More permanent impacts are the loss of organisms in and around the borrow area.

Within and immediately surrounding the borrow area, the temporarily increased turbidity will have short-term impacts. Light penetration into the water column will be reduced, lessening photosynthetic activity. Increased nutrients, resulting from resuspension of organic material, will be used as an energy source by detritus feeding organisms. These phenomena may cause a brief decrease in dissolved oxygen levels in surrounding waters. The replenishment of oxygen saturated water through constant mixing of the water column by dredging activity will minimize any dissolved oxygen reductions.

The temporarily increased turbidity will have varied effects on the flora and fauna in the area. Suspension filter and deposit feeding benthic fauna in the area of the dredge-induced plume may be affected as sediments settle and siltation occurs. The respiratory and digestive mechanisms of such organisms may become clogged by sediment particles. In the immediate vicinity of the dredge site, some organisms, may be totally buried. Some organisms, such as mussels and barnacles, cease feeding to protect themselvs during adverse conditions, including elevated levels of suspended solids. This type of sessile species would be affected only by a more prolonged period of increased turbidity. Despite a brief period of reduced photosynthesis, any affected flora will not be permanently harmed.

With regard to the fish community of the area, turbidity associated with the dredge may have the proximal effect of causing the fish to move away. A return to the area would quickly occur following abatement of the turbid conditions. On the other hand, some fish are likely to be attracted into the sediment plume to feed on resuspended benthic animals and detritus. Any healthy finfish should not be harmed by temporary increases in suspended solids.

A more permanent impact of the dredging operation will be the loss of some organisms within the borrow area. Immobile or slow moving species can be destroyed by being excavated along with the dredged sediment or by being buried. The chief loss will be that of soft-shell and some hard-shell clams. However, even in this case, the total number killed will not be substantial. Dredging will not continue to depths greater than 3 feet; the substrate of the newly created bottom will be essentially the same as that which presently exists. Repopulation of the area by colonization from nearby communities is expected to occur rapidly.

e. Impacts of Beach Nourishment. The environmental impacts of the direct placement of sandfill on the beach of the project area, while substantial, are not expected to be significantly adverse. Some habitat alteration, increased turbidity and organism destruction will occur, but these impacts will be far out weighed by increased social benefits to be derived from the improved beach.

Essentially, the nourishment will cover over the existing beach and intertidal habitats along Sherwood Island West Beach. Impacts to existing sandy areas will be virtually nonexistent. These areas are typically devoid of any population of organisms, although some widely scattered clams may be found. The newly created habitat will have a substrate of similar characteristics. This will result from the use of sandfill compatible with existing beach sands. It will be predominantly sand which is of similar size (medium to coarse grained with relatively few fines) and chemical composition to the existing sand and will be free of contaminants. In fact, that portion of sandfill dredged from Compo Cove is probably, for the most part, sand which was originally used for beach nourishment in 1957.

There will be, however, insignificant impact to rocky beach and intertidal areas such as those which exist along the eastern portion of West Beach. Existing slow moving or immobile organisms will be lost to burial and their habitat will be eliminated. Rocky beach and intertidal areas, generally a suitable habitat for various species of shellfish, algae and other benthic organisms, will be replaced by a substrate of medium to coarse sand, which will not support a productive biologic community in the intertidal and beach areas.

However, this loss of productive rocky intertidal and submerged habitat will be offset by construction of a groin. The rocks and sand interface of the groin will provide suitable replacement habitat for the

types of organisms which formerly inhabited the lost rocky area. These new habitats will be quickly colonized by organisms relocated from nearby communities. In fact, the project could increase diversity and biomass by providing a rock/sand interface, while also providing a more stable environment along the shoreline by decreasing erosion.

In general, the loss of the numbers and types of organisms present in the rocky intertidal and beach areas is not considered to be significant. These types of biological communities are found on many rocky beaches throughout Long Island Sound. In fact, these communities are naturally ephemeral, being subject to ice scour during winter and threatened by the shifting sands of the present unstablized beaches. Thus, these areas cannot be considered to be ideal locations for thriving shellfish communities.

f. Restore Valuable Recreational Area. Sherwood Island State Park receives substantial usage, in excess of one million visitors annually. In a State with as severe a shortage of public saltwater recreational capacity as Connecticut, it is essential that the existing available saltwater facility be preserved and used to the maximum degree that efficient management will allow.

With the implementation of the project approximately 500,000 square feet will be added to this area. This will increase the physical capacity of the beach by 6,700 people. This all translates to a value of $15,400 in increased recreational capacity at Sherwood Island State Park on each occasion when the improvements are use to their optimum capacity.

Also implementation of this project will ensure safe swimming conditions at the eastern section of West Beach. This area is currently composed of a rocky surface, due to erosion, which creates a dangerous environment for recreational swimmers.

V. Alternatives.

There are four proposed plans of action currently being considered for Sherwood Island State Park West Beach. Three of the alternatives involve beach widening with suitable sandfill. They also involve lowering the existing groin along with construction of an intermediate low-profile groin. The fourth plan is a shore management plan.

Plan 1 involves beach widening, to a level beach berm width (200,225 or 250 feet), by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline extending east from the existing Federal groin structure.

Plan 2 consists of beach widening to a level beach berm width (200,225 or 250 feet) and lowering the landward end of the existing groin structure located at the west limit of the study area.

Plan 3 is the favored alternative. It involves beach widening to a level beach berm width (200,225 or 250 feet), lowering the landward end of the existing groin structure, and placing an intermediate low-profile groin structure between Sherwood Point and the west limit of the study area.

Plan 4 gives guidelines for managing the use of the backshore and provides guidance to the State for future public participation in water related activities. These activities include restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dune. These activities will help the dunes to grow and help to stabilize the backshore area. The dunes will supply additional nourishment to the beach.

No Federal action means that the State will continue to regrade the beach. This alternative would cause the eventual loss of a recreational area. Presently the eastern section of West Beach is severely eroded. It consists of a rocky terrain which has become very hazardous to recreational swimmers and sunbathers. Without the implementation of some plan of action, West Beach will continue to deteriorate until this recreational facility is lost.

VI. Coordination.

The Corps of Engineers has held meetings with a variety of organizations and agencies from local, State and Federal levels. These meetings have served to supply information for the study and to inform the different organizations as to the nature of the project. This coordination will be continued up through the time of project implementation.

The Corps of Engineers implemented a walk/talk program on West Beach to encourage local participation in the project. This program provided first hand information on the proposed improvements. Also a public workshop was set up at West Beach which provided additional information on the project as well as visual aids pertaining to the project area.

The proposed action, according to Connecticut officials working on the project, is consistent with all the applicable State policies and plans, including the Connecticut Coastal Management Program, the State Conservation and Development Policies Plan and the State Comprehensive Outdoor Recreation Plan.

Coordination with the Federal agencies has also occurred. The Corps has received comments from the Environmental Protection Agency, the Fish and Wildlife Service and the National Marine Fisheries Service concerning the shellfish resources off of West Beach. Mr. Charles McElivee the Westport, Connecticut Shellfish Officer stated that West Beach contains a negligible amount of clams and is not considered a viable shellfish resource to the town. He further stated that the few clams present are

undersized and are not utilized. It was also determined that the oyster leases offshore would not be affected by the proposed project according to one of the offshore leasees.

Federal Environmental Statutes

1. Archeological and Historic Preservation Act, as amended, 16 U.S.C. 469 *et seq*.

   Coordination complete with State Historic Preservation Officer. No effect.

2. Clean Air Act, as amended, 42 U.S.C. 7401 *et seq*.

   Not applicable.

3. Clean Water Act (Federal Water Pollution Control Act), as amended, 33 U.S.C. 1251 *et seq*.

   In compliance. 404 Evaluation Report issued.

4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451 *et seq*.

   In process of compliance.

5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 *et seq*.

   None identified.

6. Estuary Protection Act, 16 U.S.C. 1221 *et seq*.

   Not applicable.

7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-12 *et seq*.

8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 *et seq*.

   Process continuing. Planning aid letter received.

9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 4601-4 *et seq*.

   Not applicable.

10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 *et seq*.

    Not applicable.

11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq.

Compliance completed with State Preservation Officer.

12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 432 et seq.

Issuance of State Environmental Report and review will constitute compliance.

13. Rivers and Harbors Appropriation Act of 1899, as amended, 33 U.S.C. 401 et seq.

Not applicable.

14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 et seq.

Not applicable.

15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 et seq.

Not applicable.

VII. Conclusion.

It is evident that the proposed Small Beach Erosion Control project posess no significant impacts on the environment that would warrant the writing of a formal Environmental Impact Statement for the following reasons.

a. Sherwood Island State Park West Beach is currently experiencing erosion especially to its eastern end. The placement of clean sandfill material of a suitable size will improve the aesthetic value and provide additional dry beach space thus increasing its recreational capacity.

b. The turbidity associated with this project will be minimal due to the fact that the material to be used is composed of medium to fine sand grain.

c. There are a few organisms that possess the ability to inhabit rocky areas such as the eastern portion of West Beach. However, this loss of productive area will be offset by construction of a groin. This area will provide a suitable replacement habitat and will be colonized by organisms relocated from nearby communities.

Therefore, the erosion control project of Sherwood Island State Park West Beach would exhibit minimal adverse effects on the environment. The proposed project would have beneficial effects for the patrons of this beach.

Finding of No Significant Impacts

The proposed Small Beach Erosion Control Project at Sherwood Island State Park West Beach, Westport, Connecticut, will provide for the placement of 90,000 cubic yards of clean sandfill as well as the placement of a rock groin structure for the purpose of erosion control.

The impacts associated with this project are threefold. First a recreational beach of sufficient size will be created and maintained. Second, there will be insignificant impact to the rocky beach and intertidal areas such as those which exist along the eastern portion of West Beach. Existing slow moving or immobile organisms will be lost to burial and their habitat will be eliminated. Rocky beach and intertidal areas, generally a suitable habitat for various species of shellfish, algae and other benthic organisms, will be replaced by a substrate of sand. The rocks and interstices of the groin will provide suitable replacement habitat for the types of organisms which formerly inhabited the lost rocky area. Third, the amount of turbidity will be small and thus its effect on the oxygen level and photosynthetic processes of plankton will be insignificant. (See Assessment, Section IV, page 35.)

The Army Corps of Engineers has made the determination that the proposed Small Beach Erosion Control Project will not have any significant impacts which would necessitate the preparation of an Environmental Impact Statement.

11 September 1981
DATE

C. E. Edgar III
C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Section 404(b) Factual Determination

and Finding of Compliance

Beach Erosion Control for Sherwood Island State Park

Westport, Connecticut

Department of the Army
New England Division, Corps of Engineers
Waltham, Massachusetts

April 1981

Section 404(b) Factual Determination
and Finding of Compliance
Beach Erosion Control for Sherwood Island State Park
Westport, Connecticut

1. References

a. Section 404(b) of Public Law 92-500, Clean Water Act
b. 40 CFR Part 230. Subparts B, C, D, E, F, G and H, dated 24 December 1980
c. EC 1105-2-90 Appendix C, dated 8 May 1979

The Proposed Project

Approximately 90,000 c.y. of fill material will be placed along the West Beach of Sherwood Island State Park. Present plans call for a portion of the fill material to be composed of naturally occurring sands dredged from Compo Cove, located immediately west of the beach area. Sediment and grain size analysis will be performed by the State of Connecticut to insure cove material is suitable for placement on the beach. Material obtained from the cove will be covered with an additional 6 ft. of suitable sand from a clean commercial land source. If material from the cove proves to be unsuitable for placement on the beach, all needed sand would then be obtained from a clean commercial land source.

The landward end of the existing Federal groin, located at the western limit of the proposed improvement area, will be lowered to allow wind-blown sand to move along the beach. An additional low profile groin will be constructed between the west limit of study and Sherwood Point. Construction material for the groin will be clean and obtained from a near-by commercial land source.

3. Project Authority

Investigations for providing beach erosion control along West Beach, Sherwood Island State Park were authorized by a resolution adopted by the Senate Committee for Public Works on 15 May 1968.

4. Environmental Concerns

The project as proposed will have only minimal temporary impacts on the local aquatic environment. No significant or persistent adverse impacts are expected for several reasons.

a. Fill material will be clean, free of any harmful contaminants and composed of naturally occurring sands from Compo Cove and/or material obtained from a near-by commercial land source.

b. Impacts associated with construction including increased turbidity, reduced light transmission and lowered photosynthetic rates are expected to be temporary since materials with large particle sizes such as sand settle rapidly when disturbed or discharged. Again because of the larger particle size of sand, all fill material will be free of contaminants that would adversely affect the local environment or render the beach unsuitable for recreation.

c. All fill material will be compatible with existing sediments. This will allow the present biological community to begin reestablishment shortly after construction is completed.

d. While construction activities are expected to destroy benthic organisms inhabiting the immediate work area both in Compo Beach cove and along West Beach, no known significant fish or shellfish resources would be affected by the project.

e. Construction of the low profile groin, while removing some intertidal and subtidal habitat, will provide a rock/sand interface with greater surface area suitable for colonization, thus allowing greater biological diversity and biomass.

f. Construction will allow continued use of a valuable recreation area.

5. Restrictions on Discharge (Section 230.10)

No practical or economical alternatives which would be capable of achieving the basic purpose of the proposed project exist. A "no action" alternative is not by definition practical since this would allow continue erosion of a public beach, and result in its eventual loss.

6. Find of Compliance (Section 230.12)

a. On the basis of these guidelines (subparts C through G) the proposed disposal site for the discharge of fill material has been specified as complying with the requirements of these guidelines.

b. The factual determinations required by Section 230.11 are presented on page 48.

7. Conclusions

Determinations

a. An ecological evaluation has been made following guidance in 40 CFR 230 Subparts B, through G. An addition, Subpart H was reviewed to determine applicability to the proposed project.

b. Appropriate measures have been identified and incorporated in the proposed plan to minimize adverse effects on the aquatic environment as a result of the discharge (See Environmental Impact Evaluation prepared by Connecticut Department of Environmental Protection, a separate document.

c. Consideration has been given to the need for the proposed project, the availability of alternate sites and methods of disposal that are less damaging to the environment, and such water quality standards as are appropriate and applicable by law.

d. In order to provide beach erosion control along West Beach, clean fill will be placed in and along the shoreline.

Findings

The proposed discharge site for the proposed beach erosion control project located at Sherwood Island State Park West Beach has been specified through the application of Section 404(b) Guidelines.

The project files and Federal regulations were reviewed to properly evaluate the objectives of Section 404 of Public Law 92-500. A public notice with respect to the 404 Evaluation will be issued accompanying this document. Based on information presented in the 404 Evaluation, I find that the project will not result in unacceptable impacts to the environment.

10 April 1981
Date

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Factual Determination
of
Potential Effects from the Proposed Discharge of
Fill Material along West Beach, Sherwood
Island State Park, Westport, Connecticut

230.11(a) Physical substrate determinations

Characteristics of the substrate at the proposed disposal site will not be significantly altered by the proposed construction. Fill material will be predominantly sand and compatible with the existing beach. A portion of this material will be obtained by dredging Compo Cove, which has shoaled in over the years, with the remaining clean sand obtained from a near-by commercial land source.

Construction of a low profile groin will convert the existing sandy substrate to one of rock. The resulting rock/sand interface is expected to provide a more stable and diverse habitat for benthic organisms and should result in increased biomass.

(b) Water circulation, fluctuation, and salinity determinations

Current patterns, circulation and normal water fluctuations will not be altered in such a manner as to result in adverse affects to the environment. Construction of the low profile groin will in fact interrupt the long shore net movement of both water and sand along West Beach. However, this should be considered a positive impact since erosion should be significantly reduced, both insuring the integrity of beach restoration and providing a more stable habitat for benthic organism residing along the shoreline and on the groin itself.

Due to the large particle size of the fill material and the fact that such material will be free of contaminants, impacts on water chemistry, salinity, clarity, color, odor, taste, dissolved gas levels, temperature should be minimal, if any occur at all.

(c) Suspended particulate/turbidity determinations

Some temporary minimal increase in ambient suspended particulate and turbidity levels is expected as a result of construction. Since sand settles rapidly, no problems are expected. And since surf zones are areas of high energy and have naturally high suspended sediment loads and turbidity levels, it is possible increased levels due to construction will not be discernable.

(d) Contaminant Determinations

All material proposed for discharge will be clean, obtained from either naturally occurring sands or from a commercial source and will be free of harmful contaminants that might adversely impact the aquatic environment or render the beach unsuitable for human use.

(e) Aquatic ecosystem and organism determination

Slow moving or immobile organisms inhabiting the immediate construction area are expected to be destroyed. Widening the beach will extend seaward the tide line, effectively removing once intertidal substrate from the aquatic environment. However, once construction is completed the "new" intertidal area will be suitable for establishment by the previous community with nearby communities providing recruitments for colonization. In addition, construction of a low profile groin should increase diversity and biomass by providing a rock/sand interface while also providing a more stable environment along the shore line by decreasing erosion.

(f) Proposed disposal site determinations

Not applicable. This section addresses the acceptability of and impacts associated with mixing zones. Mixing zones apply to open water disposal techniques. No open water disposal of fill material will occur in conjunction with the proposed project.

(g) Determination of cumulative effects on the aquatic ecosystem (1 and 2)

Except for the periodic beach nourishment that has taken place at Sherwood Island State Park, no known Federal, State or local actions which would affect the aquatic environment at or near Sherwood Island have occurred. And, since the last beach nourishment occurred in 1957, no cumulative impacts resulting from the proposed project are expected.

(h) Determination of secondary effects on the aquatic ecosystem

Possible secondary impacts associated with construction might include interference with spawning or reproductive processes of fish and shellfish. In order to avoid this problem, construction will occur during the fall and early spring months.

RECOMMENDATIONS

The Division Engineer recommends the plan discussed in the previous section "Recommended Plan" is the most practical, economical and environmentally suitable plan of improvement for West Beach of Sherwood Island State Park Westport, Connecticut. Approval of the beach erosion control project by the Chief of Engineers is recommended under the provisions of Section 103 of the River and Harbor Act of 1962, as amended. The approval, with such modifications that the Chief of Engineers may deem advisable, is estimated to have a total first cost of $960,000 which includes the cost of the first year of periodic nourishment. The total project cost, including periodic nourishment for the 50-year period of evaluation is $1,989,000. This cost excludes any preauthorization cost which is currently estimated at $115,000.

I further recommend that Federal participation be authorized in the amount of 70 percent of the first cost of construction of the project, which is estimted to be $960,000 and annual periodic nourishment for the 50 years of economic analysis. The Federal share of the first cost is $672,000.

This recommended Federal beach erosion control study with Federal participtION is subject to the following conditions of local cooperation:

1. The local sponsor (State of Connecticut) should agree that it will:

a. Contribute prior to construction, in cash, 30 percent of the first cost of construction, including the cost of plans and specifications (total project costs are currently estimated to be $959,400); a final apportionment of first costs will be made after actual costs and values have been determined.

b. Assume full responsibility for all project costs in excess of the Federal cost limitation of $1,000,000, which includes the cost of periodic sand nourishment for the 50-year economic life of the project and all study costs.

c. Maintain continued public ownership of the park and shore and its administration for public use during the 50-year economic life of the project by establishing, prior to construction, a boundary control line which will separate public property from private property used for the realization of the public benefits upon which Federal participation is based.

d. Provide, witout cost to the United States, all lands, easements, and rights-of-way necessary for project construction and subsequent maintenance of the project.

e. Hold and save the United States free from all claims for damages that may arise before, during, or after prosecution of the work and subsequent maintenance of the project other than damages due to the fault or negligence of the United States or its contractors.

f. Maintain the protective measures during the economic life of the project as may be required to service their intended purpose by contributing, in cash, 100 percent of the cost of groin maintenance and 30 percent of the cost of periodic sand nourishment for the life of the project. The estimated amount of periodic sand nourishment is 3,000 cubic yards annually. Such contributions are to be made prior to each nourishment operation.

g. Control water pollution to the extent necessary to safeguard the health of bathers.

h. Comply with the requirements of non-Federal cooperation specified in Section 210 and 305 of Public Law 91-646, approved 2 January 1971, entitled the "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

i. Comply with Title VI of the Civil Rights Act of 1964 (78 Stat 241) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

ACKNOWLEDGMENT AND IDENTIFICATION OF PERSONNEL

This report was prepared under the supervision and management of the following New England Division personnel:

Colonel C.E. Edgar, III, Division Engineer
Joseph L. Ignazio, Chief, Planning Division
Donald W. Martin, Chief, Coastal Development Branch

The study and report was developed by Thomas Bruha, Project Manager, assisted by Cathy LeBlanc, James Doucakis, Frank Fessenden, and Janet Martin of the Beach Erosion Unit; Stephen McMullin prepared the economic material; Lt. Harry Morgan prepared the social resources material; Dave Dupee prepared the Environmental Assessment; John Wilson prepared the cultural resources material; James O'Leary prepared the design material; Chuck Wener prepared the hydrologic material; and Eugene Brickman and Timothy Beauchemin performed the sand source search.

The New England Division is appreciative of the cooperation and assistance rendered in connection with this study by the following personnel of other Federal offices and agencies: Win Robinson and Fred Benson, U.S. Fish and Wildlife Service; and Michael Ludwig, National Marine Fisheries Service. Also the following personnel of the State of Connecticut: Stanley Pac, Commissioner, Dept. of Environmental Protection; William Miller, Director, Parks and Recreation, (Dept. of Environmental Protection); and Robert Leach and Jane Kreisman, Coastal Area Management Program, (Dept. of Environmental Protection). Also the following local interests: Jacqueline Heneage, First Selectman, town of Westport, Connecticut: the Compo Cove Association President; and Mr. Bruce Porter of the Compo Cove Association.

APPENDICES

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APPENDIX 2	FORMULATION, ASSESSMENT, AND EVALUATION OF DETAILED PLANS
APPENDIX 3	PUBLIC VIEWS AND RESPONSES
APPENDIX 4	[illegible] INVESTIGATIONS, DESIGN, AND COST ESTIMATES
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APPENDIX 1

PROBLEM IDENTIFICATION

PROBLEM IDENTIFICATION

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PROBLEM IDENTIFICATION

This appendix contains detailed information which will supplement information contained in the main report. The needs of the area are considered in this appendix and the problems prevalent in the area as a result of the continuing erosion are identified.

STUDY AUTHORITY

This report was authorized, in a 1st Indorsement letter dated 10 July 1980 by the Chief of Engineers, Washington, DC, under the authority granted in Section 103 of the River and Harbor Act of 1962, as amended for Small Beach Erosion Control Reports. Section 103 provides authority for the Chief of Engineers to develop and construct small shore and beach restoration and protection projects that have not already been specifically authorized by Congress. After a detailed investigation and study clearly shows the engineering feasibility and economic justification of the project, only then will the project be adopted for construction under Section 103. Each project must be complete, economically justified, and limited to a Federal cost of not more than $1,000,000. This Federal cost limitation includes all project related costs for the report preparation, construction, investigations, supervision and administration. A small beach erosion control project developed under Section 103 is formulated to provide the same complete-within-itself project that would be recommended under regular authorization procedures. No additional work should be required to assure effective and successful operation of the project. An increment or portion of a larger overall project is not eligible for construction under this program.

OTHER STUDIES AND REPORTS

A beach erosion control report was completed in 1949 by the Corps of Engineers, in cooperation with the State of Connecticut, for the reach of shorefront between Ash Creek and Saugatuck River. The result of this report was a recommendation for Federal participation in the construction of several beach erosion control improvements for the reach, including Sherwood Island State Park. This report was published in House Document No. 454, 81st Congress, 2nd Session.

An interim hurricane survey report was completed in 1961 for Westport, Connecticut. This report, published in House Document No. 412, 87th Congress, 2nd Session, recommended Federal participation in a hurricane protection project for the nearby Compo Cove Beach area. In 1964, a

second interim hurricane survey report was completed for Connecticut coastal and tidal areas. This report is published in House Document No. 146, 89th Congress, 2nd Session.

In May 1967, the Coastal Engineering Research Center completed Technical Memorandum No. 20, "Behavior of Beach Fill and Borrow Area at Sherwood Island, Westport, Connecticut." This study reviewed the existing problems at Sherwood Island and made pertinent recommendations for improvements.

A reconnaissance report was completed in 1968 by the Corps of Engineers, in response to the 5 January 1966 request from the Water Resources Commission, State of Connecticut (now called the Department of Environmental Protection). It was completed in accordance with the authority of Section 103 of the River and Harbor Act of 1962, as amended by Section 310 of the River and Harbor Act of 1965. This report recommended that a full scope beach erosion control survey report be undertaken.

A Beach Erosion Control Study of Sherwood Island was undertaken by the Corps of Engineers in November 1974. This included a review of the 1949 report completed by the Corps in cooperation with the State of Connecticut. Due to lack of local cooperation, this study was deferred. The State, however, requested that the study be set aside; they wanted to be able to have the study reactivated when they were able to provide the cooperation necessary.

A study was performed in September 1979 by Flaherty Giavara Associates, P.C. and Raytheon which looked at shoreline stabilization of Sherwood Island State Park and the Compo Cove area plus the restoration of Sherwood Mill Pond. This study determined that some of the improvements made by the State at Sherwood Island State Park in 1975 and 1976 actually had some adverse effect on the Compo Cove area. Improvements to be made to the existing structures and additional new structures were recommended in this study.

PROBLEM IDENTIFICATION

Sherwood Island State Park is a very popular recreational area which includes a beach area with backshore facilities such as a bathhouse, picnic tables, a ball playing area, a pavilion containing a restaurant, and large grassy areas. Located in Westport, Connecticut, approximately 10 miles west of Bridgeport, Connecticut and 50 miles east of New York City, the park has one of the only beaches in the area open to the general public. The beach itself is divided by Sherwood Point into two distinct bathing areas, known as East Beach and West Beach. East Beach has remained relatively stable over the years; however, West Beach has experienced a serious erosion problem, due to the overtopping of the beach

during frequent serious winter storms. As this erosion continues, the available dry beach space decreases. The decreasing dry beach space, combined with the popularity of the park, creates an overcrowding condition. The area is also very rocky and as the erosion continues, more rocks are exposed, which creates a safety problem for the bathers.

Close coordination and contact was maintained throughout the course of the study with State and local officials to determine the needs, demands, and requirements for the project area. Several plans of improvement were evaluated and presented to State and local officials for their comments and approval or disapproval. Both structural and non-structural plans were evaluated from engineering, economic, and environmental standpoints.

The main objectives in solving the problems at Sherwood Island are identifying the water resource problems and creating a successful solution that is acceptable to everyone concerned. The development of the opportunities necessary for solving these problems involved the type of management measures that are appropriate to provide the needed water related recreational planning.

At the present time, other than any Federal project, the only choices remaining are either to leave the beach alone and allow it to continue to erode, or have the State nourish the beach annually in an attempt to keep ahead of the erosion. Due to the fact that the State, at the present time, cannot afford to nourish the beach, the only alternative open to them would be to continue to regrade the beach as they have been in the past.

EXISTING BEACH CONDITIONS

West Beach, which is the only beach being considered, extends for approximately 1,800 feet between Sherwood Point and the existing Federal groin structure. There is little or no dry beach bathing area above the mean high waterline on sections of the beach near Sherwood Point. However, the west part of the beach is fairly wide and very heavily used. The inner end of the groin structure, located at the westerly limits of the study area, was raised by the State in February 1976.

DESCRIPTION, COMPOSITION OF SHORE, AND PROTECTIVE STRUCTURES

Sherwood Island State Park beach is divided into two distinct beaches known as East Beach and West Beach. Since the East Beach has remained relatively stable over the years, this study will only be concerned with West Beach. The information presented in this section has been obtained from field investigations and historical data.

West Beach:

Location - Sherwood Point westward to existing Federal groin structure.

Shore Length - Approximately 1,800 feet

Ownership - State of Connecticut

Public Facilities - First aid station and grassy area with picnic facilities (all located along the backshore)

Composition of Shore - From Sherwood Point west for about 1,200 feet, the beach is very rocky with no sandy beach available. The remaining 600 feet of this section is sandy above the mean high waterline and contains small scattered rocks and gravel intermixed with sand below the mean high waterline.

Surface samples were taken along the shoreline at various points as indicated on Plate 1-1, and grain size analyses were performed on these samples. Based on these analyses, gradation curves were plotted which present certain soil characteristics. These curves are shown in Figures 1-1 through 1-33. An attempt will be made, based on these curves, to obtain sandfill for the project which has similar characteristics to the sand which is now found on the beach. Standards for sand characteristics have been established from information in the Shore Protection Manual and will be utilized at the time of final plans and specifications to determine the most suitable sandfill for the project.

HISTORIC SHORELINE CHANGES

Shoreline changes were determined from all available survey data from 1883 through 1980. These changes are shown on Plates 1-10 and 1-11. A summary of the changes is given below.

West Beach extends for approximately 1,800 feet west of Sherwood Point. Based on the 1955 survey, prior to construction the beach width above mean high water averaged approximately 20 feet. When the authorized project was constructed in 1957 the average beach width varied from approximately 150 feet at the western end to 230 feet at the eastern end. In 1971, based on the Corps of Engineers survey, the width of the beach at the western end was 260 feet and along the easterly two-thirds of the beach, the beach widths varied from 120 feet to 180 feet. According to aerial photographs taken by the Corps of Engineers in 1978, the first 600 feet of the beach, measured from the existing Federal groin eastward,

had an average beach width of approximately 100 feet; the second 600 feet had an average beach width of about zero feet; and the beach width on the third 600 feet averaged approximately 25 feet.

NATURAL FORCES

The objective of this section is to discuss the natural forces related to Sherwood Island and show what impacts these forces will have on the study area. The natural forces include tides, winds, waves, storms, and hurricanes. Information will be included on extreme conditions of the past and the damage that has been done. The geomorphology of the area and the movement of material as a result of the natural forces will also be discussed.

TIDES

The tides in the study area are semidiurnal with spring range of 8.0 feet and a mean range of 7.0 feet (MHW) which is 4.1 feet above the National Geodetic Vertical Datum (NGVD). The frequency of occurrence of the tides with varying elevations has been computed for Sherwood Island, based on guage data done in Bridgeport, Connecticut. These tide data stage frequencies are shown in Figure 4-3.

EXTREME TIDES

Although Sherwood Island is located at the western end of Long Island Sound, it has experienced various high astronomical tides and tropical depression tides. Some examples of such tides were experienced during the 1938 and 1954 hurricanes. These hurricanes produced the highest tides ever recorded in this area. These storm surges created stillwater elevations of 13.7 feet in 1938 and 13.2 feet in 1954.

The storms which have created the largest problem to the beach are those which occur more frequently than hurricanes. For example, the "Blizzard of '78" lasted over several tide cycles and caused large amounts of erosion and structural damage.

A tabulation of selected storm and hurricane tidal levels and frequencies as determined for the Hurricane Survey for Westport, Connecticut is presented in Table 1-1.

WINDS

Included in the study of winds are two wind roses (see Plate 1). They were prepared based on local climatological data as published by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration for the State Airport at Block Island and Laguardia Airport, New York. The combination of these two areas is believed to best represent

TABLE 1-1

TIDAL ELEVATIONS AND FREQUENCIES
SELECTED STORMS AND HURRICANES

Type	Date of Storm	Tidal Flood Stillwater Level (1) Feet M.L.W.	Frequencey No./years
Hurricane	21 September 1938	13.7	1/50
Hurricane	31 August 1954	13.2	1/40
Storm	25 November 1953	12.4	1/15
Hurricane	14 September 1944	12.3	1/15
Storm	7 November 1953	12.2	1/12
Storm	12 November 1968	11.7	1/7
Storm	19 February 1960	11.4	1/5
Hurricane	12 September 1960	11.2	1/4
Storm	16 February 1958	10.5	1/2
Stroms	Ordinary storms	10.0	1 or more per year

(1) NOTE: Easterly storms of 1950, 1953 and 1968 produced a tidal surge of a hurricane or near hurricane level.

the study area. Block Island is similar to the Sherwood Island shorefront in that it has flat terrain without physical obstructions to the wind movement. The available data shows that the predominant winds are from the westerly and northwesterly directions. Wind speeds greater than 35 miles per hour are not unusual in this area.

STORMS

A storm is a weather condition with sustained wind speed. This wind speed, depending on its direction, duration, and fetch distance, has the potential of generating large waves that could impact the study area. The Connecticut coast experiences frequent northeasterly through southwesterly storms. These storms cause the greatest damage to the study area since the longest fetchs are from these directions. Hurricanes, although less frequent, occur occasionally and have substantially higher tide levels.

The storm systems which have caused the greatest amounts of erosion have been the northeasterly and easterly storms. These storms build up inside the Sound and are generally slow moving; thus, the storm surge build up lasts through several tide cycles. Easterly storms such as these have occurred in November of 1959, 1953, and 1968 and have created tidal surges of a hurricane or near hurricane level.

HURRICANES

A hurricane by definition is "an intense cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 MPH (65 knots) for several minutes or longer at some points."

Although in recent history there has only been a few recorded hurricanes in the area, the records show that they have caused the most severe tidal flooding and have sustained more serious damage to shorefront structures than any other storms. The hurricanes which have caused the largest amounts of damage occurred in the years 1938, 1954, 1944, and 1960 in order of magnitude. The hurricane of 1938 produced the highest recorded tides and caused thousands of dollars worth of damage to shorefront homes.

WAVES

The data available on waves is limited to field observations of curve heights, direction of approach, period, and wave length. The configuration of West Beach, with the reveted Sherwood Point protruding out at the eastern end, restricts the exposure to threatening waves coming in from east-southeast through the southwest quadrants. Sherwood Island is located in Long Island Sound so storm waves that approach the beach are waves that have developed in the Sound. Deep-water ocean waves coming up the coast and in from deeper waters are stopped by Long Island. Therefore, fetch distance, wind velocity and duration, although of primary

importance, were not controlling factors in arriving at the design criteria. Depth of water at the beach plus short period waves, wave run up, and stillwater elevations were critical factors in establishing a design wave that determined design elevations of the level beach berm.

GEOMORPHOLOGY

The beaches of Sherwood Island State Park originated as barrier beaches which were formed by the encroachment of the sea. These barrier beaches were separated from the mainland by a shallow lagoon, which contained several small islands. Eventually tidal currents and streams flowing into this lagoon deposited mud and silt. Over time, these deposits formed a tidal marsh where the lagoon once was. With time, the barrier beaches continued to encroach on the land, and the marsh was completely filled in resulting in the present land form.

LITTORAL DRIFT

Significant littoral drift occurs in this area only under influence of storm-generated waves. Examination of historical photographs and maps indicates that the shoreline along the West Beach has suffered losses and a redistribution of sand. A study of waves and wave refractions, and observations of the area reveal a strong littoral drift moving from the east to west. As a result of this littoral movement there exists a scoured beach area extending for approximately 600 feet directly to the west of Sherwood Point. In the past this area was partially renourished by the westerly littoral movement of sand from offshore of the point; however, rock revetment placed at the point has limited this process. The material transported away from the scoured area is carried to the west where it eventually stockpiles on the east side of the existing Federal groin. Prior to the raising of this groin by the State of Connecticut the sand was wind blown onto the shoreline along Compo Cove. The net result of the existing situation is an interrupted natural westerly drift of sand, leaving one section of beach unreplenished and another section of beach stockpiled with sand.

The normal tide range within the project area is 7.0 feet with a spring range of 8.0 feet. Hydrologic studies using historical and wind data, coupled with fetch lengths, indicate that this shorefront area is subject to tidal surges of northeast through southwest sotrms. The storm wave heights vary from between 4 and 8 feet and occur at periods of between 4 and 6 seconds. The most damaging storm driven waves approach the beach from the east and cause the strongest westerly littoral movement. Storm waves approaching from the southeast also cause a similar westerly littoral movement but to a lesser degree.

The wave refraction analysis indicates substantial littoral movement in the immediate vicinity of the point with a rapid offshore movement and a strong alongshore movement for a short distance to the west. Waves approaching from the southwest are affected by nearby islands and turn to

cause moderate westerly littoral movement along sectors of the West Beach with further rapid offshore movement at the point and reduced offshore movement at the western half of the West Beach.

. : composition of littoral materials within the tidal range is either coarse sand or gravel and cobbles. The latter condition is particularly the case at the point and for some distance to the west of the Point which is extremely rocky.

PRESENT USE

The entire West Beach is available to the general public for recreational bathing. The first 600 feet of the beach, from the existing groin eastward, is in satisfactory condition. The remainder of the beach, however, is in poor condition. The entire 1,200 feet of this area is very rocky in the nearshore area, of which 600 feet has no dry beach space available. This nearshore contains exposed cobbles and is considered hazardous.

Facilities within the State Park include a pavilion which contains a restaurant, a bathhouse, sanitary facilities, picnic tables, ball playing areas, and large grassy areas. In the mid-sixties, attendance began to drop off and the State believes that this was due to the erosion problem. The State performed some work on the beach to help control the erosion problem, and at the present time the attendance at the beach is rising again. This rise in attendance is mainly due to the combination of the fact that there are no other beaches in the area open to the general public and the work that the State is doing with regrading the beach. Although the State is regrading the beach in an attempt to provide additional dry beach space, they cannot keep up with the demand. Sherwood Island presently cannot sufficiently accommodate all the bathers on popular good weather beach days. The problem of insufficient usable beach space above the mean high waterline will continue and worsen until a substantial restoration of protection improvement is done.

BEACH NEEDS

Sherwood Island, being one of the only beaches in the area open to the general public, has been experiencing a growing problem with over-crowding. This beach was very popular following the 1957 construction and in the mid-sixties, park use increased to over three times its design capacity. The numbers decreased substantially after that and the State believes that it was due to the deterioration of the beach. The fact that this beach is one of the only ones in the area open to the general public, combined with the ongoing erosion problem, creates a condition of over-crowding at the beach. Another problem caused by the erosion problem is

one of safety to the bathers. The area in question is very rocky and as the erosion continues, rocks are exposed in the nearshore area. Due to this condition, several bathers have suffered from rock bruises and cuts. There is a definite need for improvements to the West Beach at Sherwood Island State Park.

WITHOUT PROJECT CONDITION (NO FEDERAL PROJECT)

The present average rate of erosion in the study area is estimated at 4 feet per year. This continual problem of erosion and redistribution of beachfill occurs during frequent storms and rare hurricanes. The storm tides are frequently experienced with a flood level above the constructed beach berm and with waves that generally overtop the beach. Wave energy is greatly intensified at the protruding rocky point causing accelerated losses at and along the adjacent area to the west of the point. The intense wave energy at the point, with substantial loss of beachfill has resulted in a very rocky area, much of which is now unsuitable for bathing use. The continued narrowing and lowering of the beach exposes the area to increasing wave energy with losses of the remaining beach continuing at a rate believed equal or greater than has been experienced in the past. If nothing is done to improve this situation, valuable recreational beach area will continue to erode away and there will be an eventual loss of backshore land and structures.

PLANNING CONSTRAINTS

Planning constraints direct plan formulation and restrict impacts by placing limitations on the proposed plans of improvement. These limitations cover a wide range of concerns, including natural, social, environmental, economic, and legal aspects.

Sherwood Point contains popular fishing areas. One planning constraint which must be considered is to avoid the adverse effects of construction on these areas.

At the western limit of West Beach, the Federal groin structure separates West Beach from Compo Cove Beach.

The State's financial capabilities are limited; therefore, this must be considered when making the final plan selection. The plans which are fomulated must not put unreasonable financial burdens on the State.

Based on the above considerations, the following planning constraints were established:

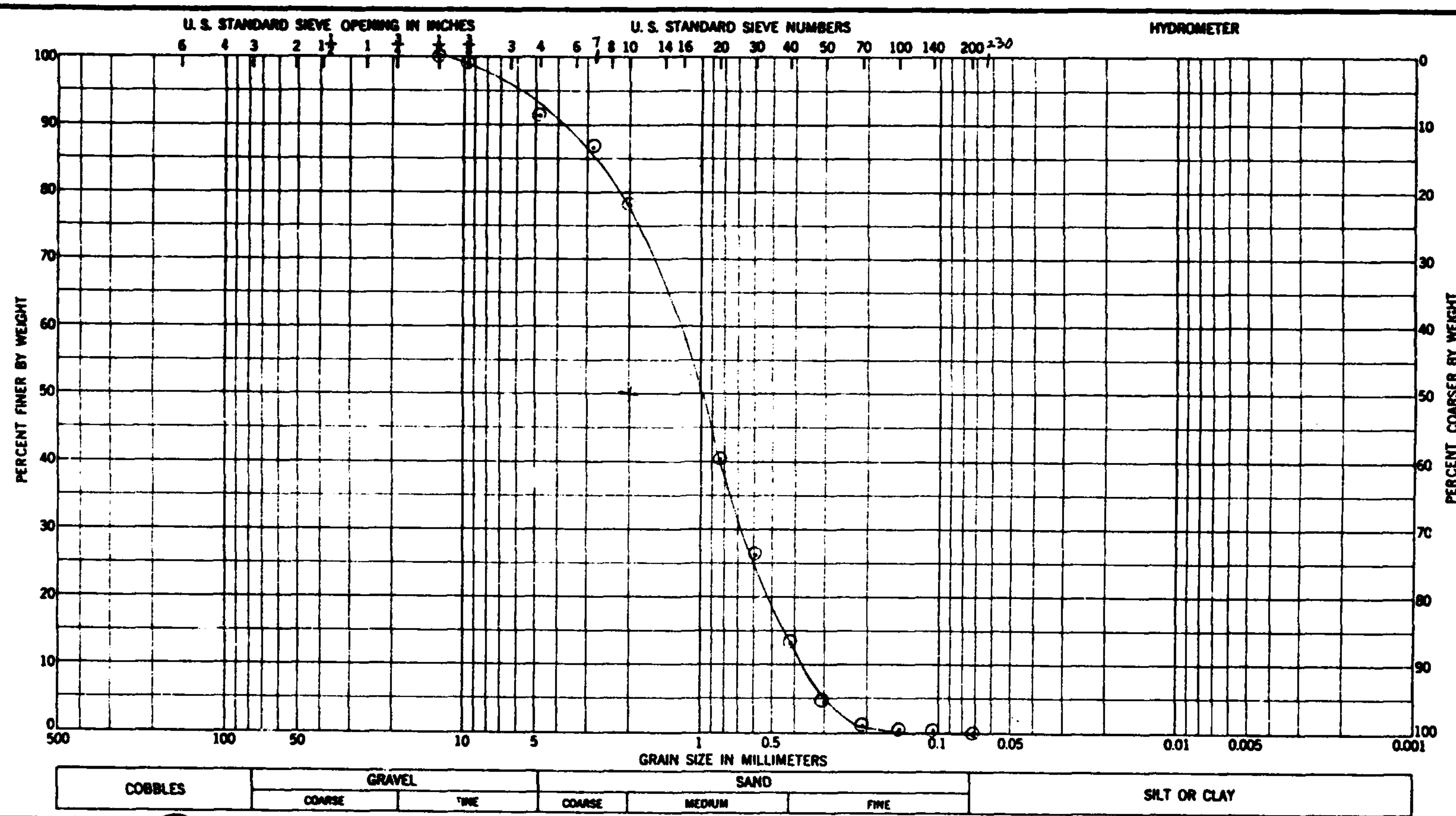
- Avoid adverse effects on the nearshore fishing areas.
- Minimize the impacts of structures on adjacent shore configurations.
- The State's financial responsibilities will be kept to a minimum.

PROBLEM AND OPPORTUNITY STATEMENTS

Problem and opportunity statements can enhance the accounts of National Economic Development (NED) and Environmental Quality (EQ). They are national, State, and local water and related land resource management needs and are specific to a given area. Problem and opportunity statements are essential in the evaluation of the various plans studied. They are determined by analyzing the problems, needs, and opportunities of the area.

In this study, five problem and opportunity statements were established for the 50-year period of analysis life of West Beach:

- Contribute to the safety of the users of the beach.
- Contribute to the economic strength and well being of the area.
- Preserve the environmental quality of the area.
- Contribute to the continued recreational use of the beach.
- Contribute to the stability of the beach.



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 6 Back of Beach	11.0	Light brown, gravelly, coarse to fine sand(SP) with shell fragments				

Project: Sherwood Island, Westport, Connecticut

Area: Profile #6

Lab Ser. #73-314-18

Date: January 1981

GRADATION CURVES

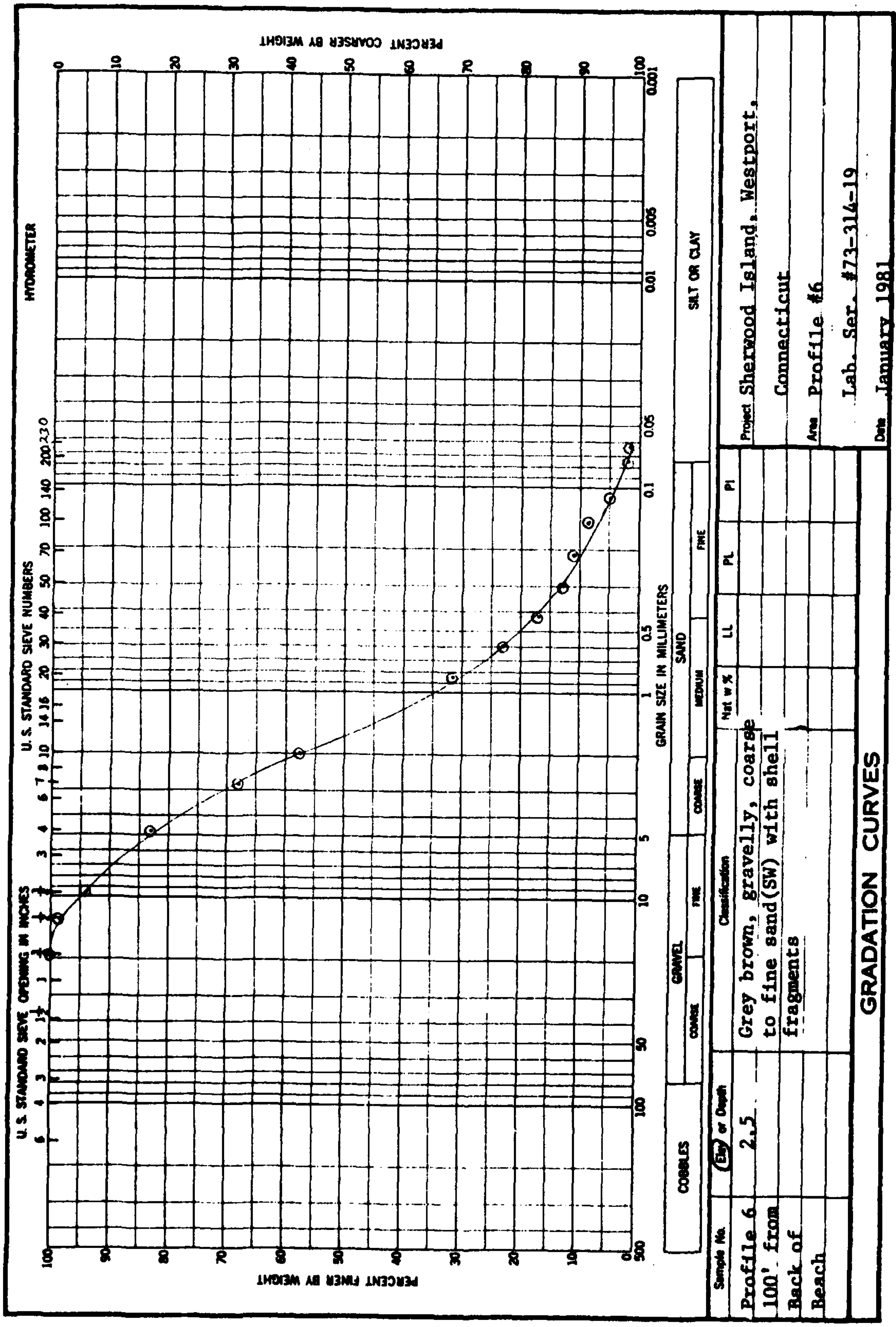
ENG FORM 1 MAY 63 2087

figure 1-1

AD-A119 864 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
WEST BEACH, WESTPORT, CONNECTICUT, SHERWOOD ISLAND STATE PARK. --ETC(U)
SEP 81

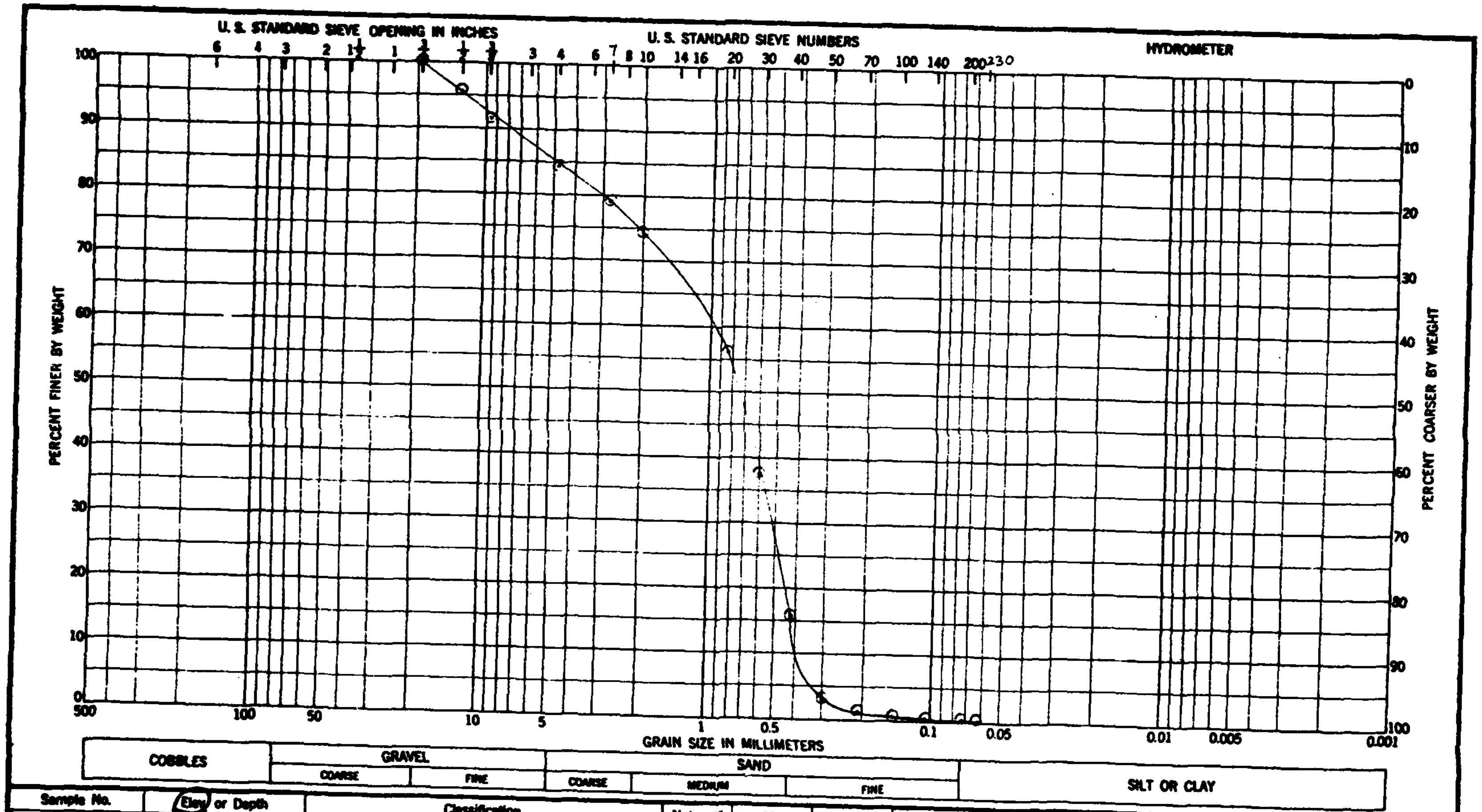
UNCLASSIFIED NL

2 of 4



U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 6
100' from
Back of
Beach
2.5
Grey brown, gravelly, coarse to fine sand(SW) with shell fragments
Project Sherwood Island, Westport, Connecticut
Area Profile #6
Lab. Ser. #73-314-19
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-2



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 6 275' from Back of Beach	0.4	Light brown, gravelly, coarse to fine sand(SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #6

Lab Ser. #73-314-20

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-3

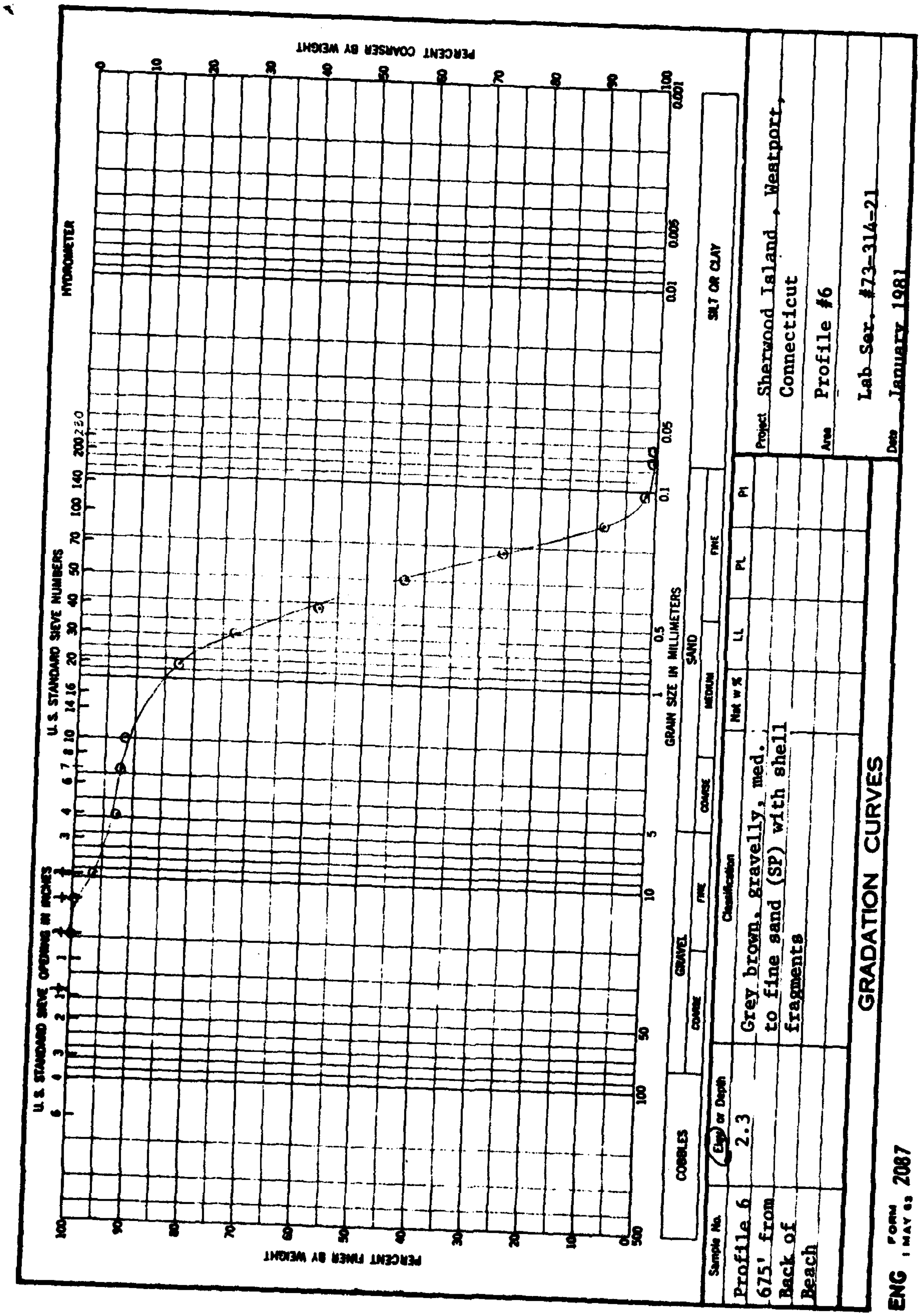
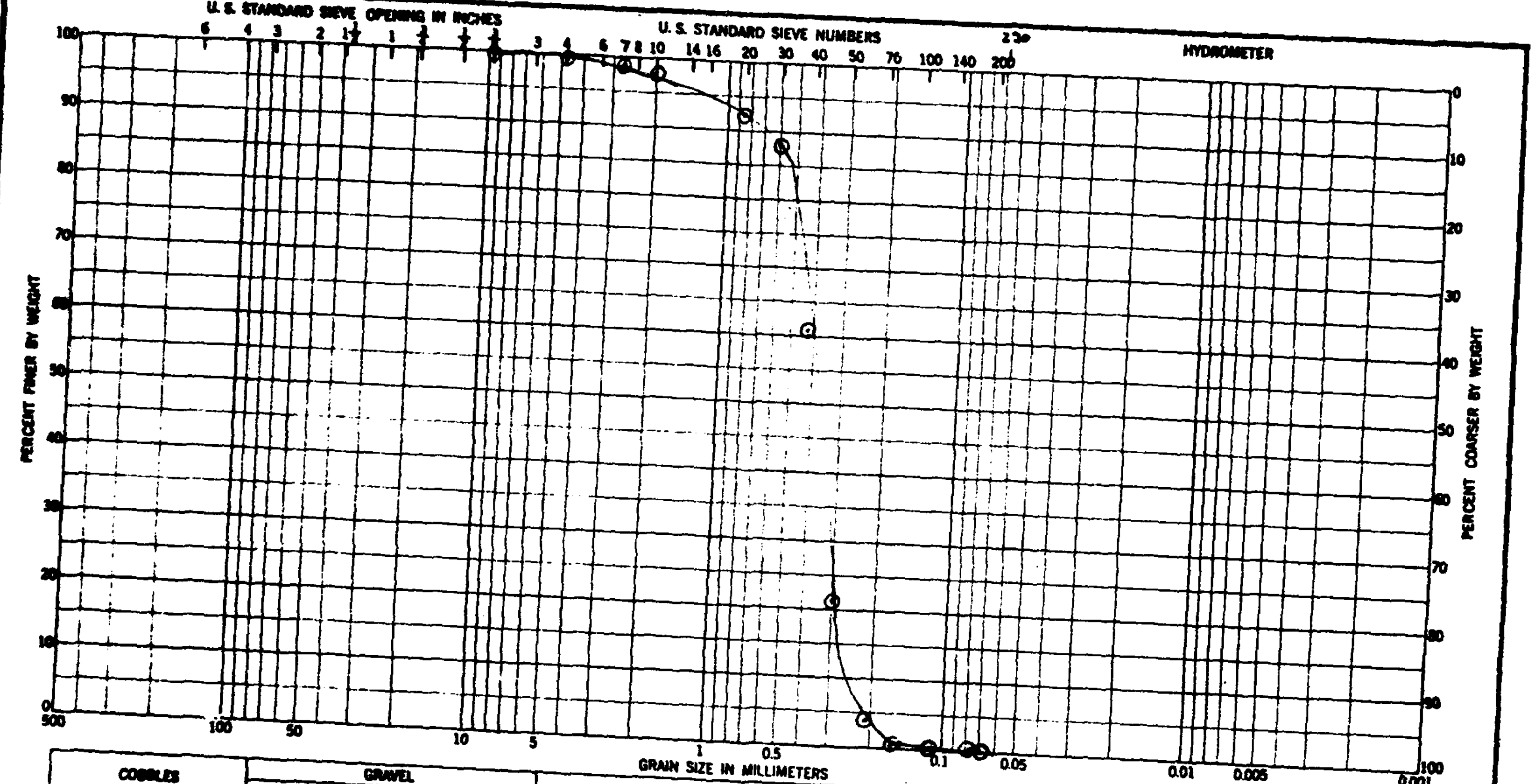

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Profile 6
675' from
Back of
Beach
Elev or Depth
2.3
Classification
Grey brown, gravelly, med.
to fine sand (SP) with shell
fragments
Nat w %
LL
PL
PI
Project Sherwood Island , Westport,
Connecticut
Area Profile #6
Lab Ser. #73-314-21
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-4



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 8 -42' from Back of Beach	13.5	Light brown, med. to fine sand (SP) with shell frag.				

GRADATION CURVES

Project Sherwood Island, Westport, Connecticut

Area Profile #8

Lab Ser. #73-314-27

Date January 1981

ENG FORM 1 MAY 63 2087

figure 1-5

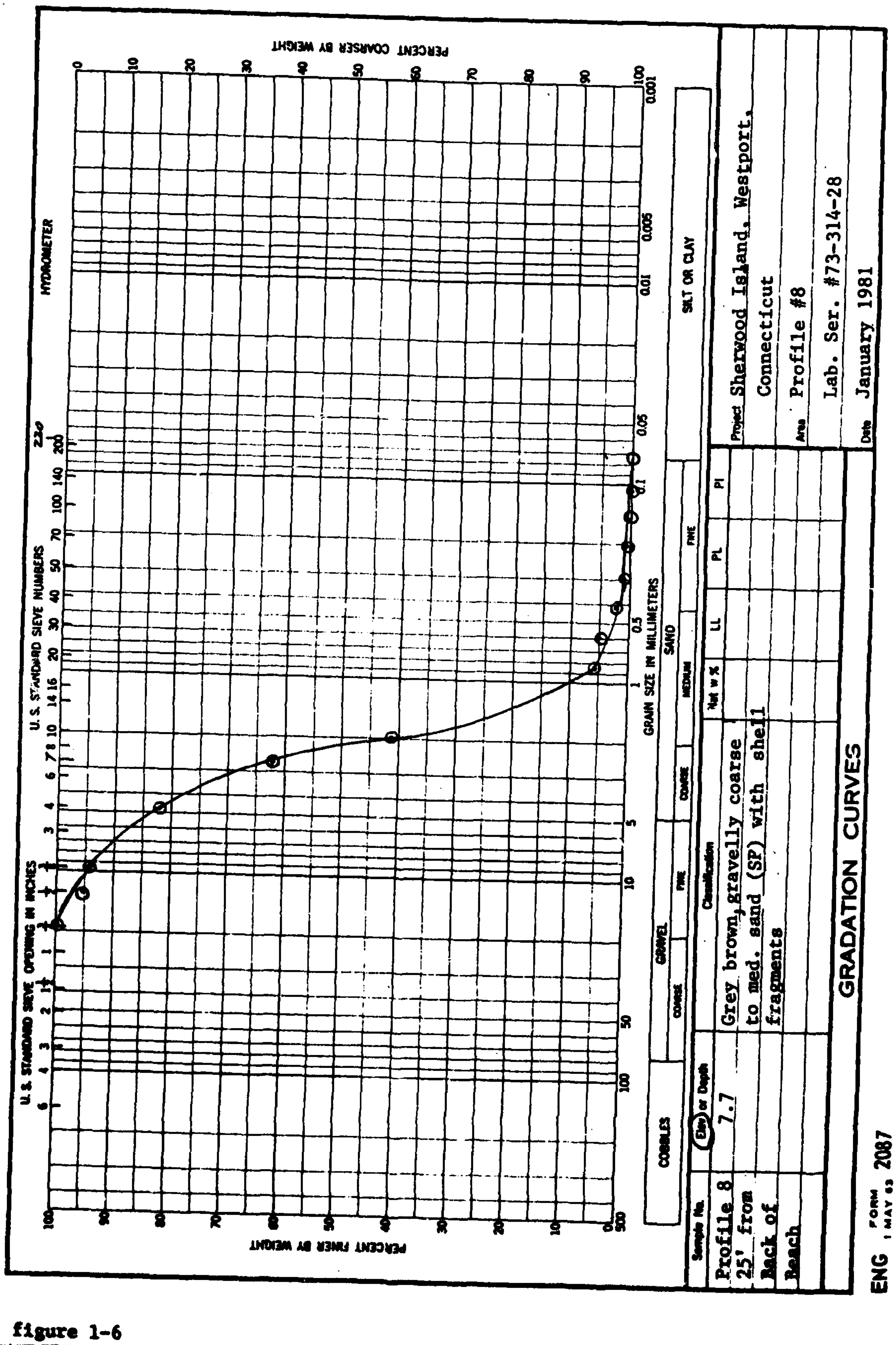
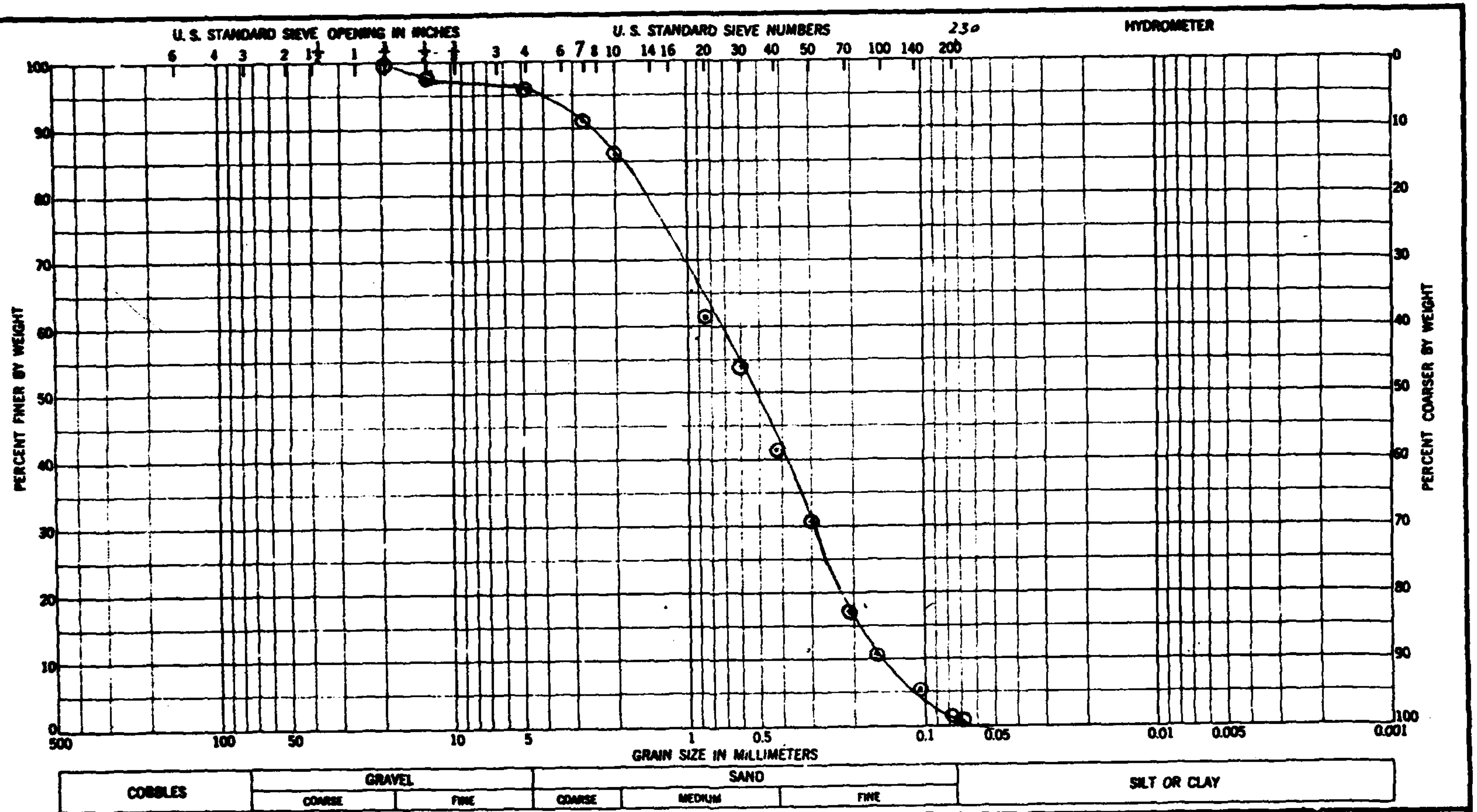

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 8 25' from Back of Beach
7.7
Grey brown, gravelly coarse to med. sand (SP) with shell fragments
Project Sherwood Island, Westport, Connecticut
Area Profile #8
Lab. Ser. #73-314-28
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-6



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 8 150' from Back of Beach	1.1	Grey brown, coarse to fine sand(SP) with shell frag.				

Project Sherwood Island, Westport, Connecticut

Area Profile #8

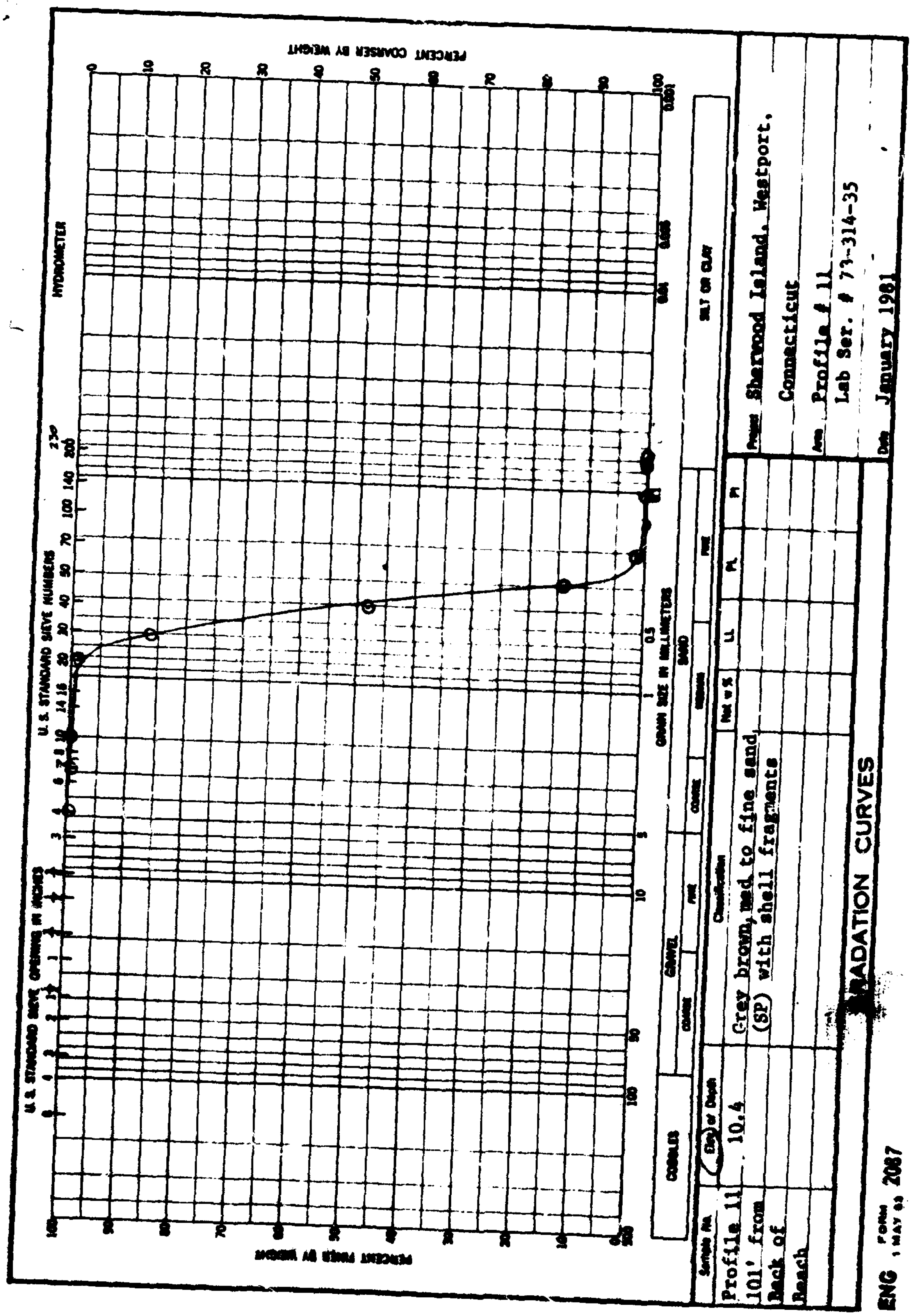
Lab ser. #73-314-29

Date January 1981

GRADATION CURVES

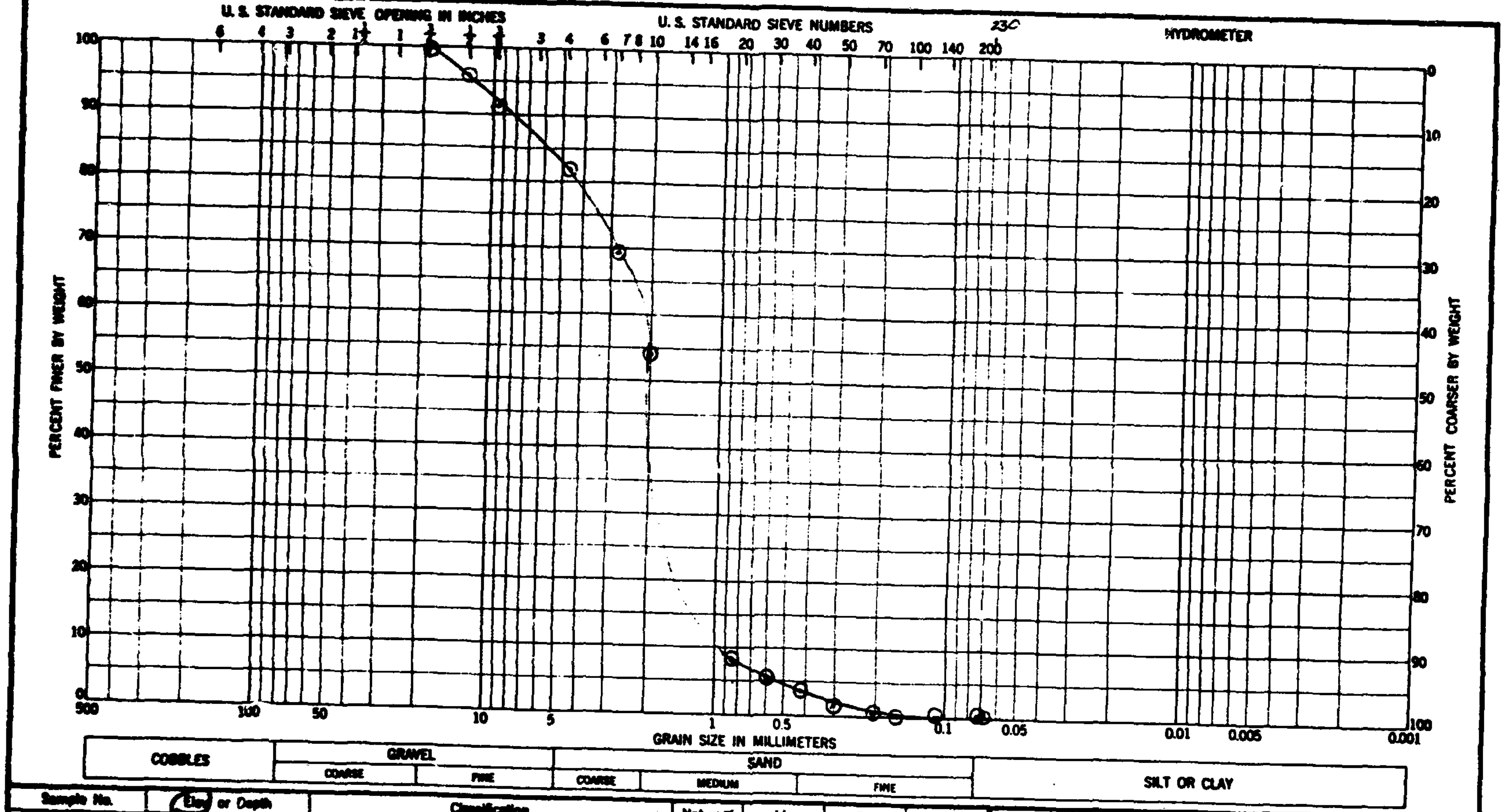
ENG FORM 1 MAY 63 2087

figure 1-7



PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
MEDIUM
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 11 101' from Back of Beach
10.4
Grey brown, med to fine sand (SP) with shell fragments
Project Sherwood Island, Westport, Connecticut
Area Profile # 11
Lab Ser. # 73-314-35
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-8



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 11 225' from Back of Beach	0.4	Light grey, gravelly, coarse to med. sand(SP) with shell fragments				

Project	Sherwood Island, Westport, Connecticut
Area	Profile# 11
	Lab Ser. #73-314-36
Date	January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-9

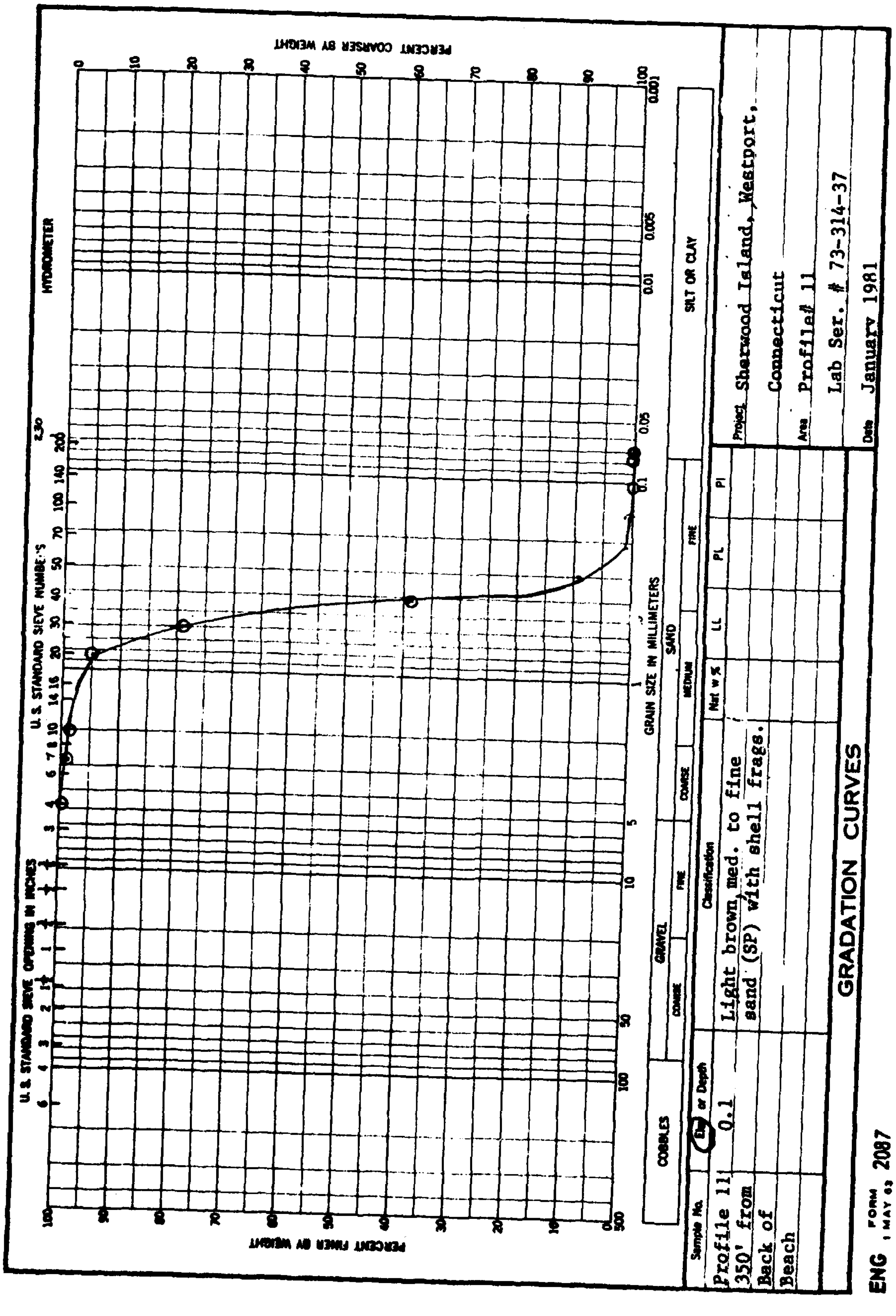
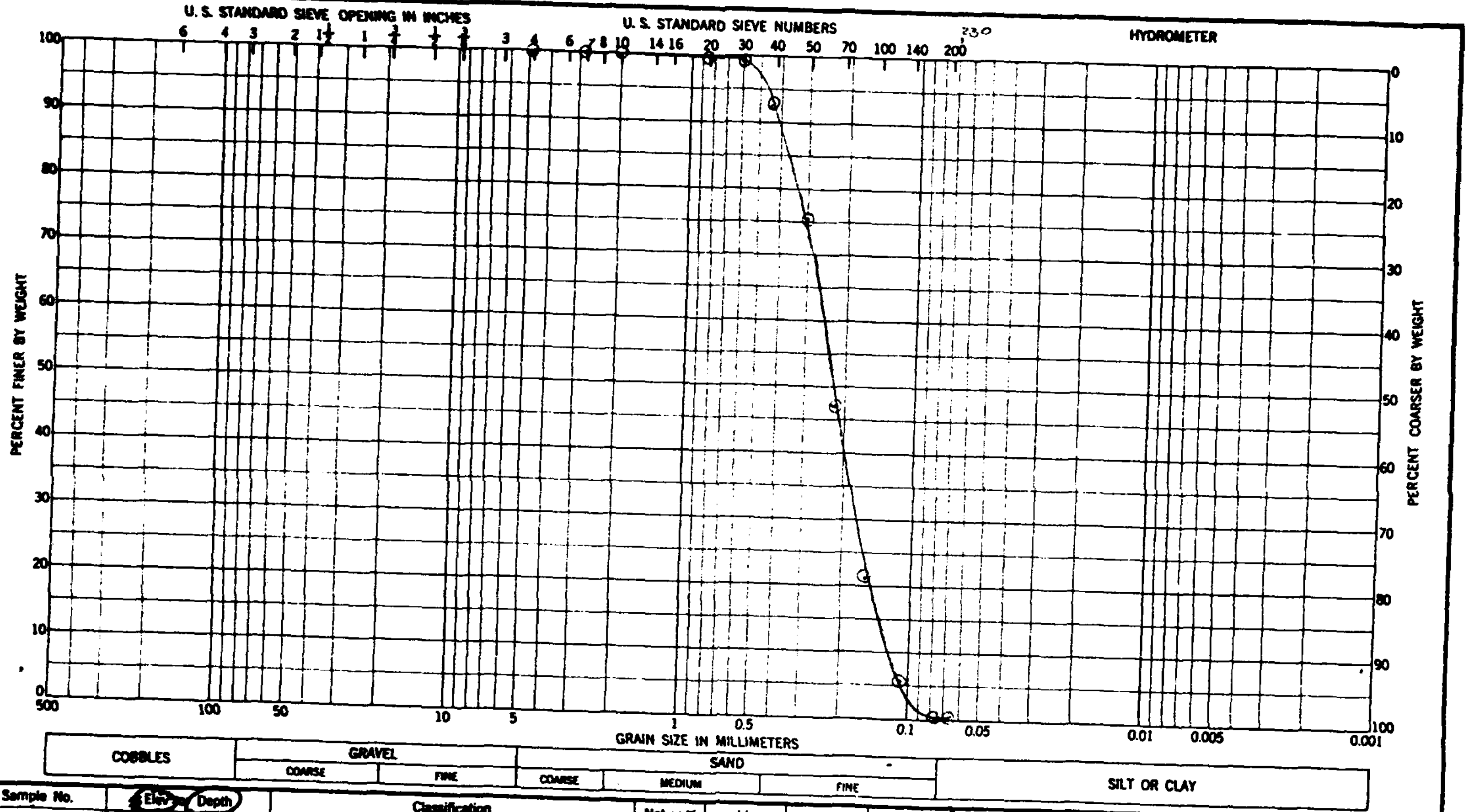

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 11 350' from Back of Beach
0.1
Light brown med. to fine sand (SP) with shell frags.
Project Sherwood Island, Westport, Connecticut
Area Profile# 11
Lab Ser. # 73-314-37
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-10



Sample No.	Elev Depth	Classification	Nat w %	LL	PL	PI
Profile 11 750' from Back of Beach	3.2	Grey brown, fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile# 11

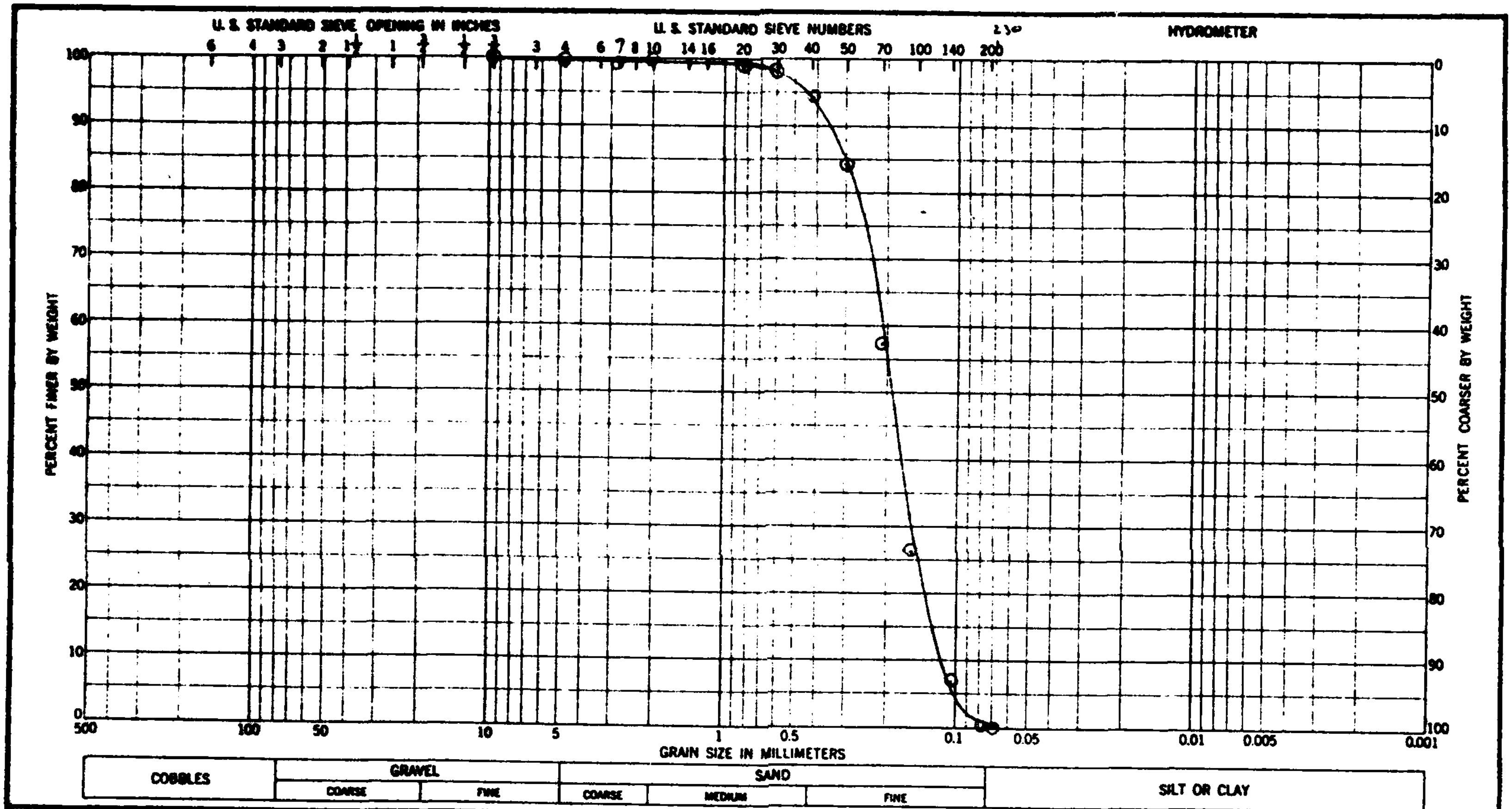
Lab Ser. #73-314-38

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-11



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 11 1000' from M.H.W.	9.2	Grey brown, fine sand (SP) with shell fragments				

GRADATION CURVES

Project: Sherwood Island, Westport, Connecticut

Area: Profile #11

Lab Ser. # 73-314-39

Date: January 1981

ENG FORM 1 MAY 63 2087

figure 1-12

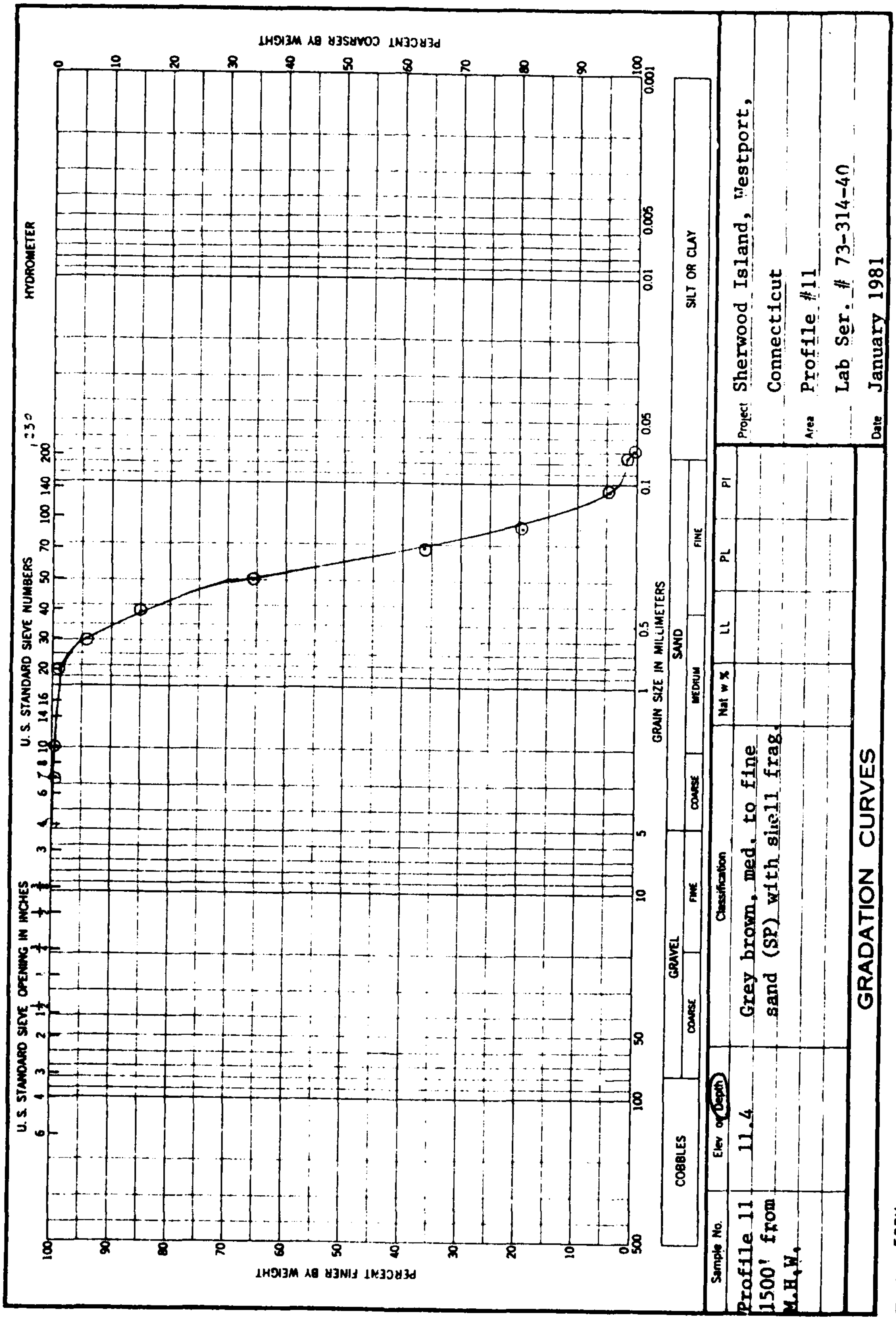
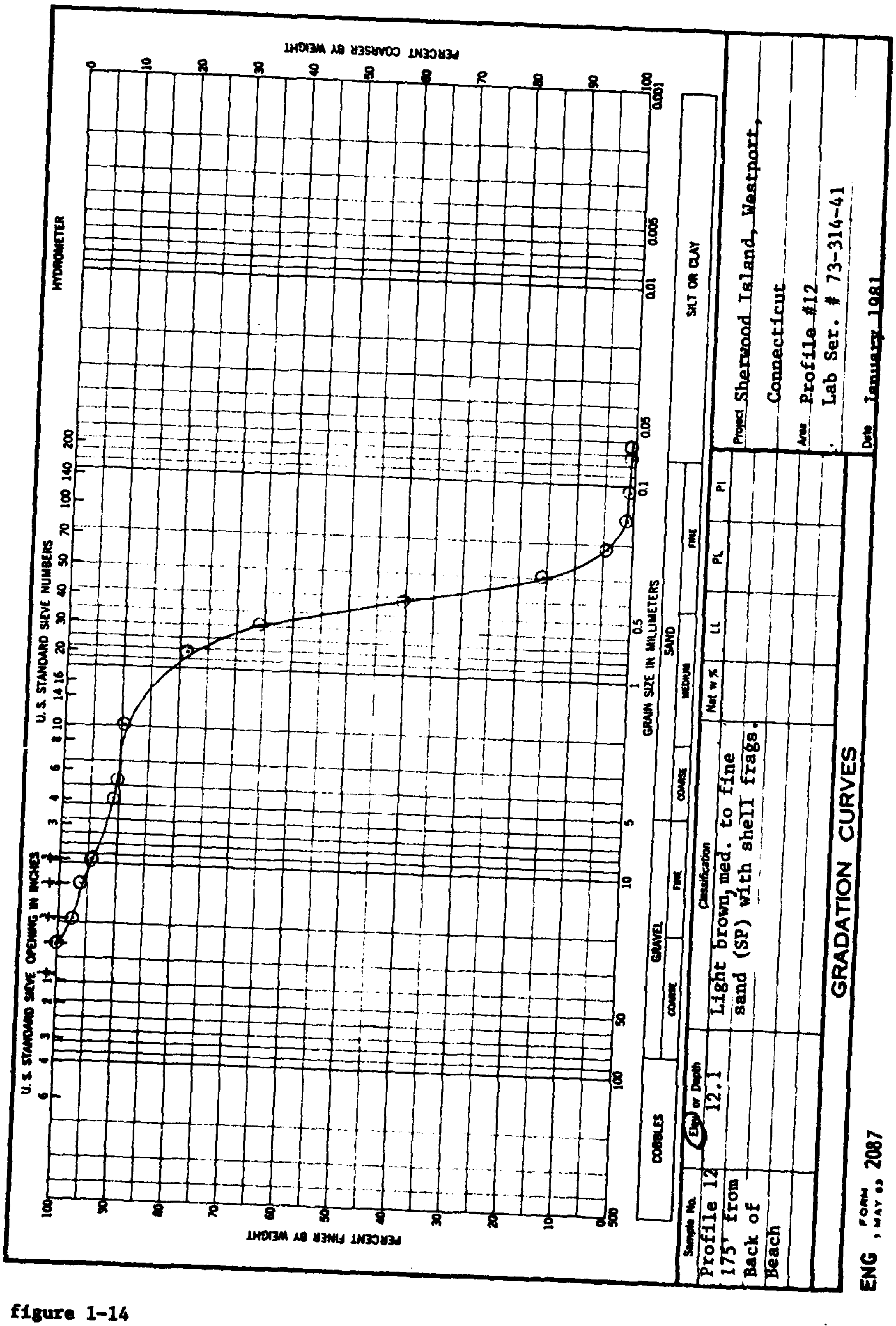
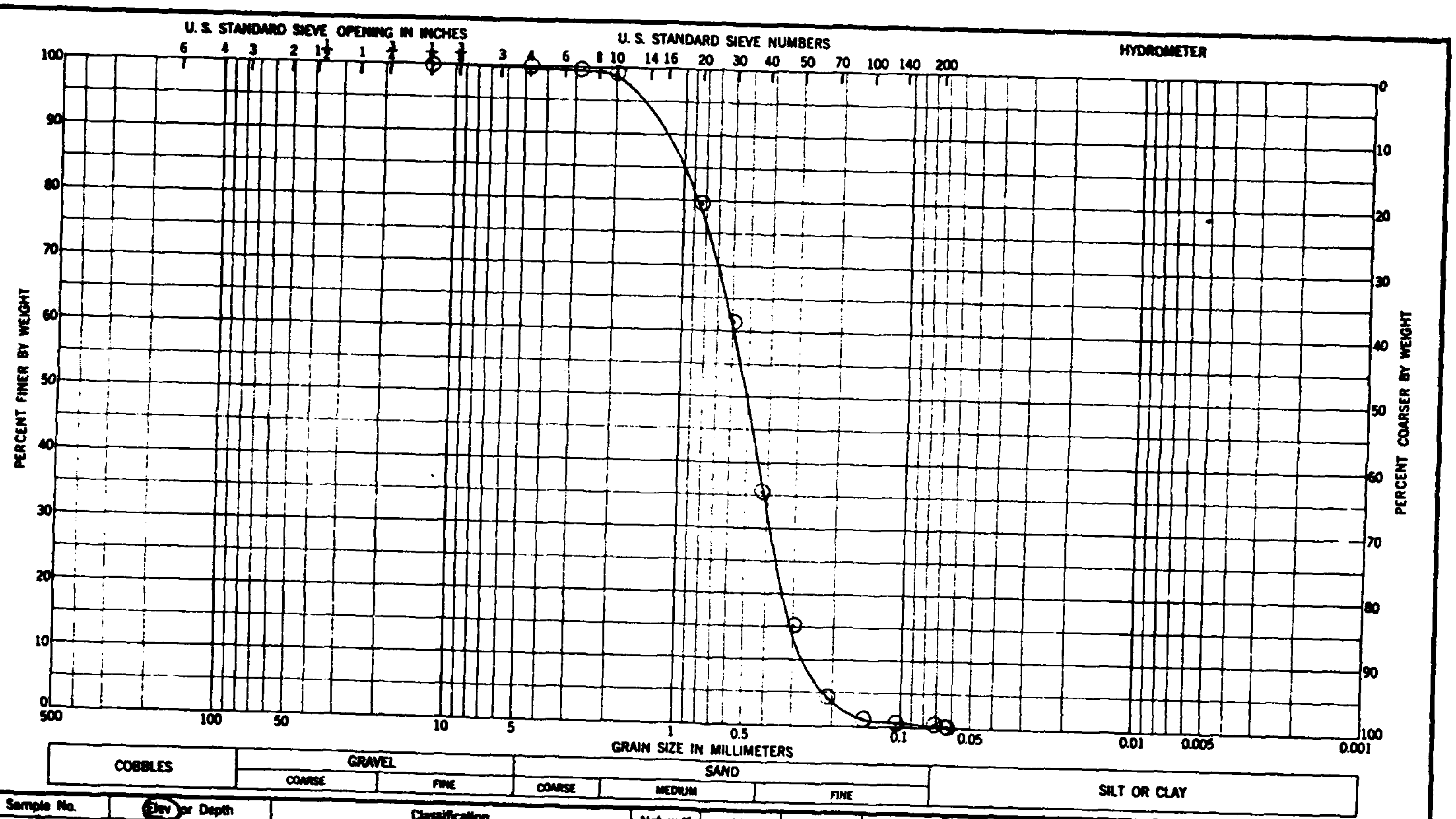

U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Profile 11
1500' from
M.H.W.
Elev or Depth
11.4
Classification
Grey brown, med. to fine
sand (SP) with shell frag.
Nat w %
LL
PL
PI
Project Sherwood Island, Westport,
Connecticut
Area Profile #11
Lab Ser. # 73-314-40
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-13



PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Profile 12
175' from
Back of
Beach
Elev or Depth
12.1
Classification
Light brown, med. to fine
sand (SP) with shell frags.
Nat w %
LL
PL
PI
Project Sherwood Island, Westport,
Connecticut
Area Profile #12
Lab Ser. # 73-314-41
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-14



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 12, 275' from Back of Beach	10.8	Light brown, med. to fine sand(SP) with shell frags.				

Project Sherwood Island, Westport, Connecticut

Area Profile #12

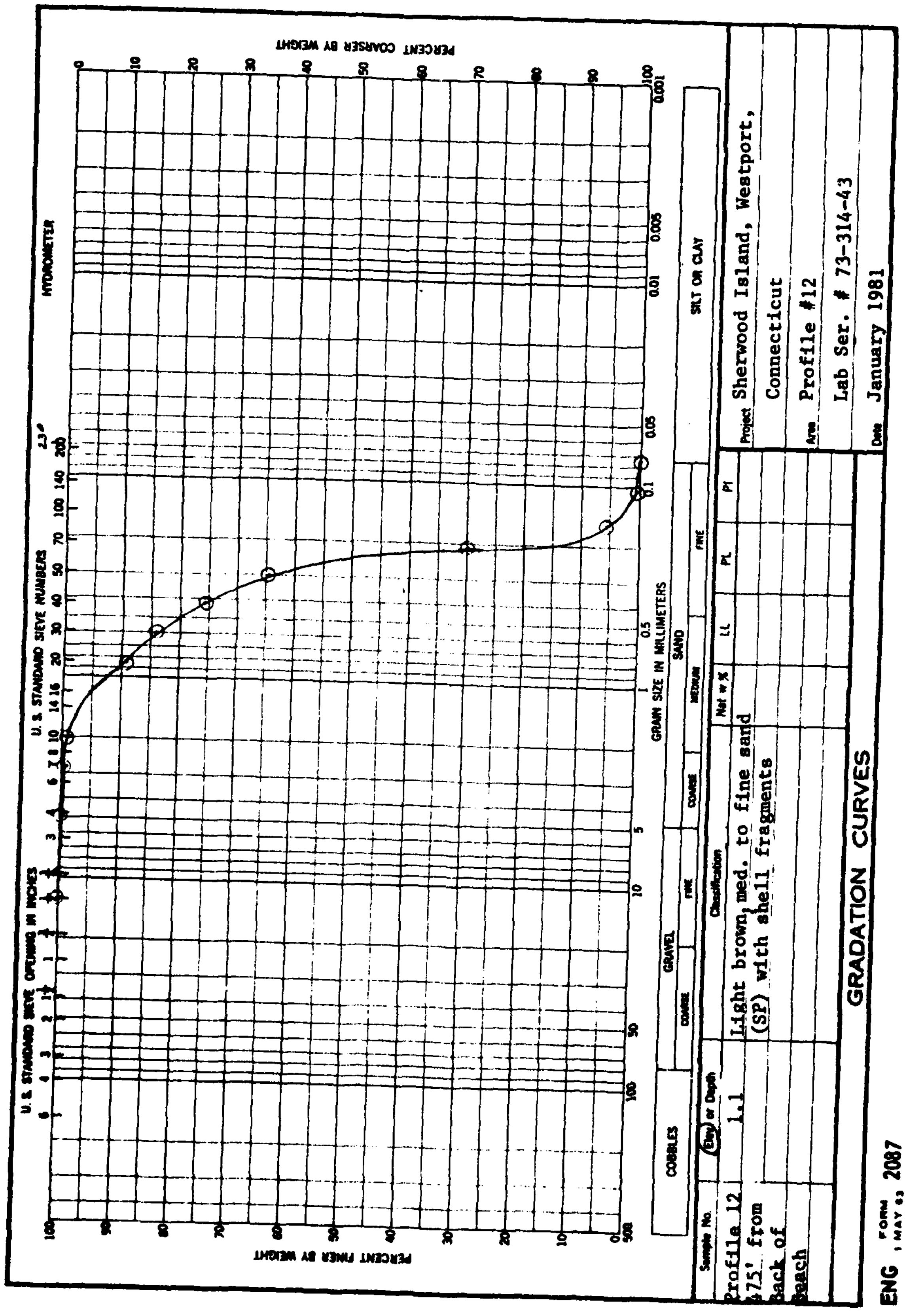
Lab Ser. # 73-314-42

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-15



U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Profile 12
475' from
Back of
Beach
Elev or Depth
1.1
Classification
Light brown med. to fine sand
(SP) with shell fragments
Nat w %
LL
PL
PI
Project Sherwood Island, Westport,
Connecticut
Area Profile #12
Lab Ser. # 73-314-43
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-16

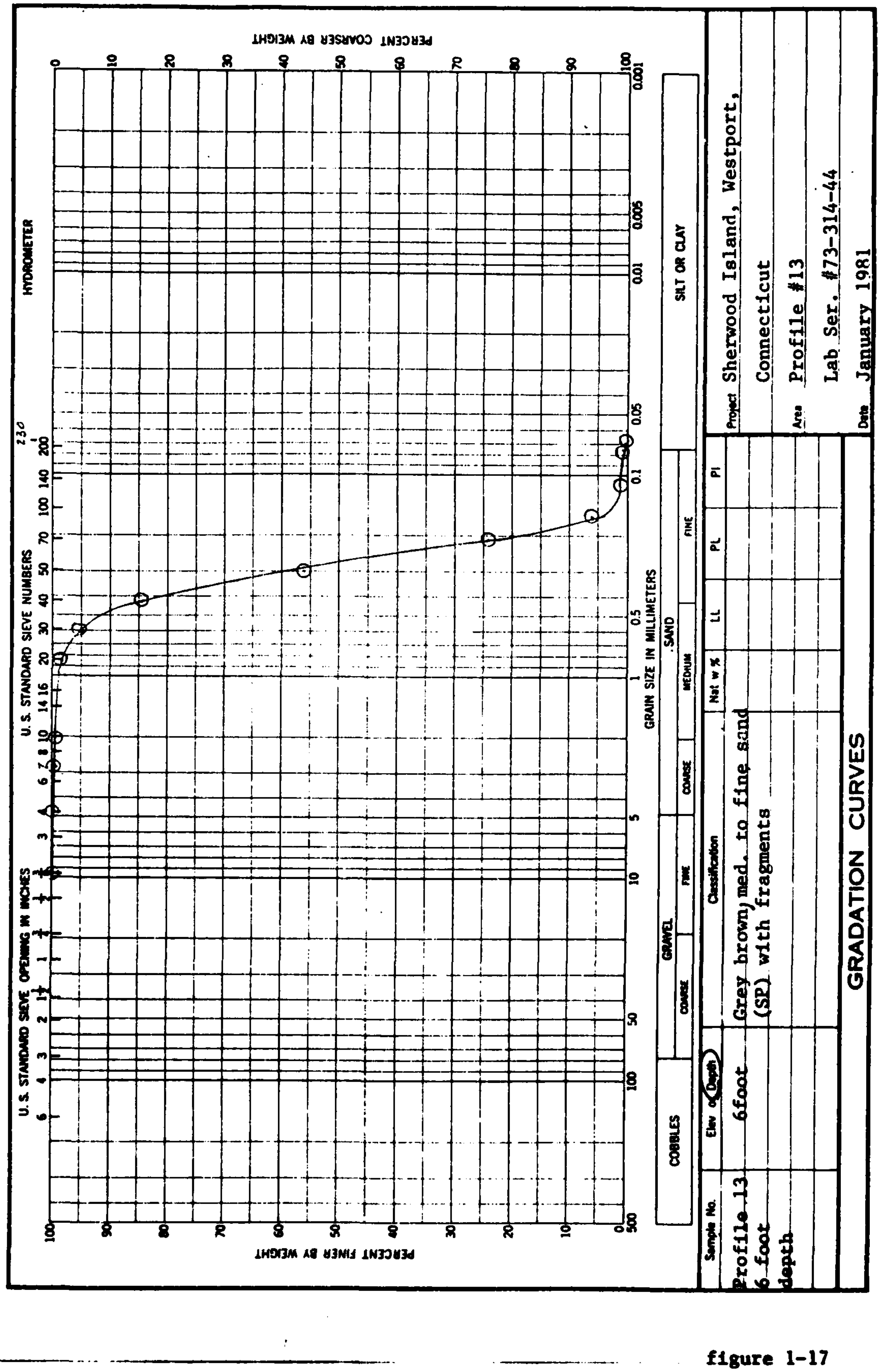
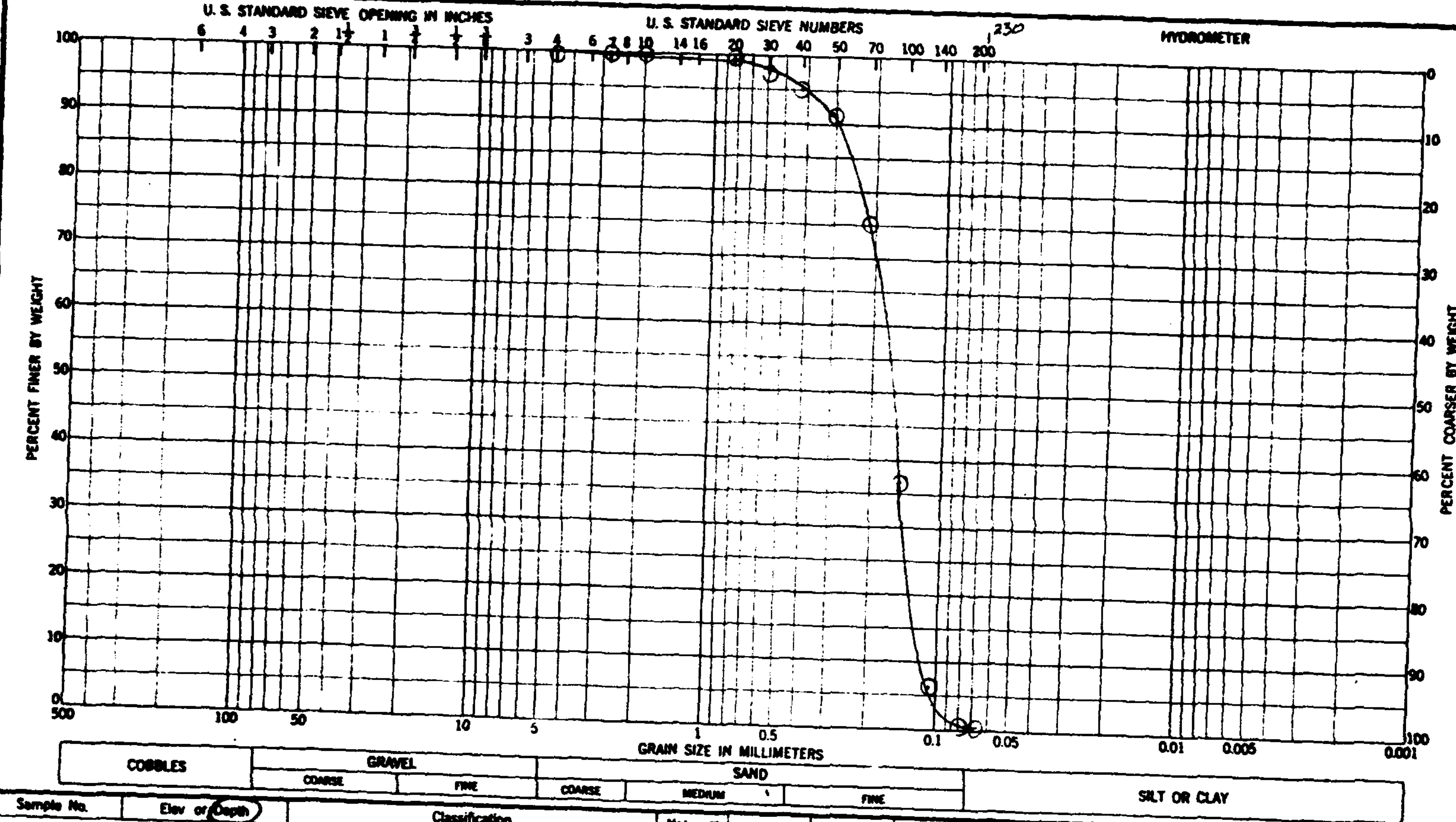

PERCENT COARSER BY WEIGHT
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 13
6 foot
depth
6foot
Grey brown, med. to fine sand
(SP) with fragments
Project Sherwood Island, Westport,
Connecticut
Area Profile #13
Lab Ser. #73-314-44
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-17



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 13 12 foot depth	12 foot	Grey brown, fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #13

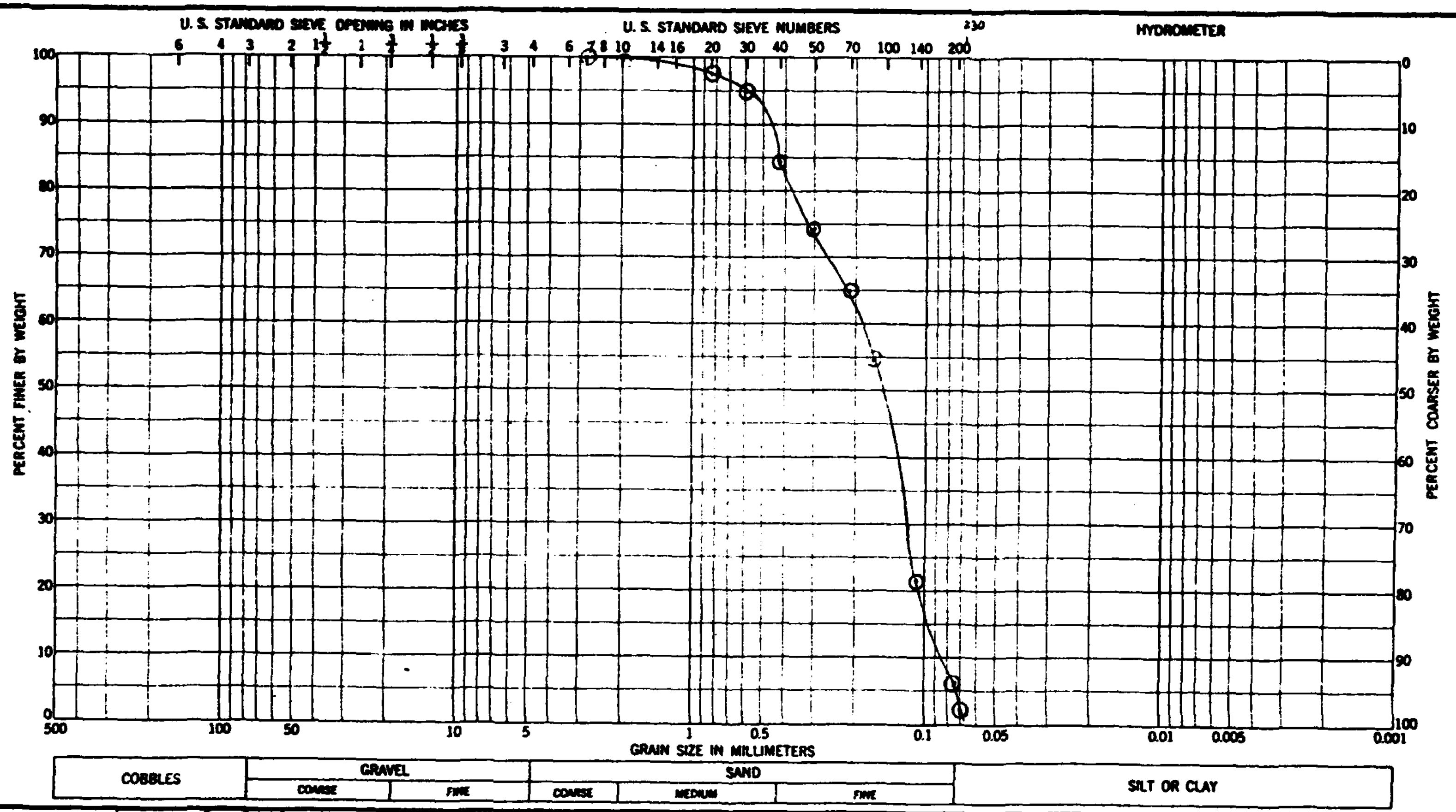
Lab Ser. #73-314-45

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-18

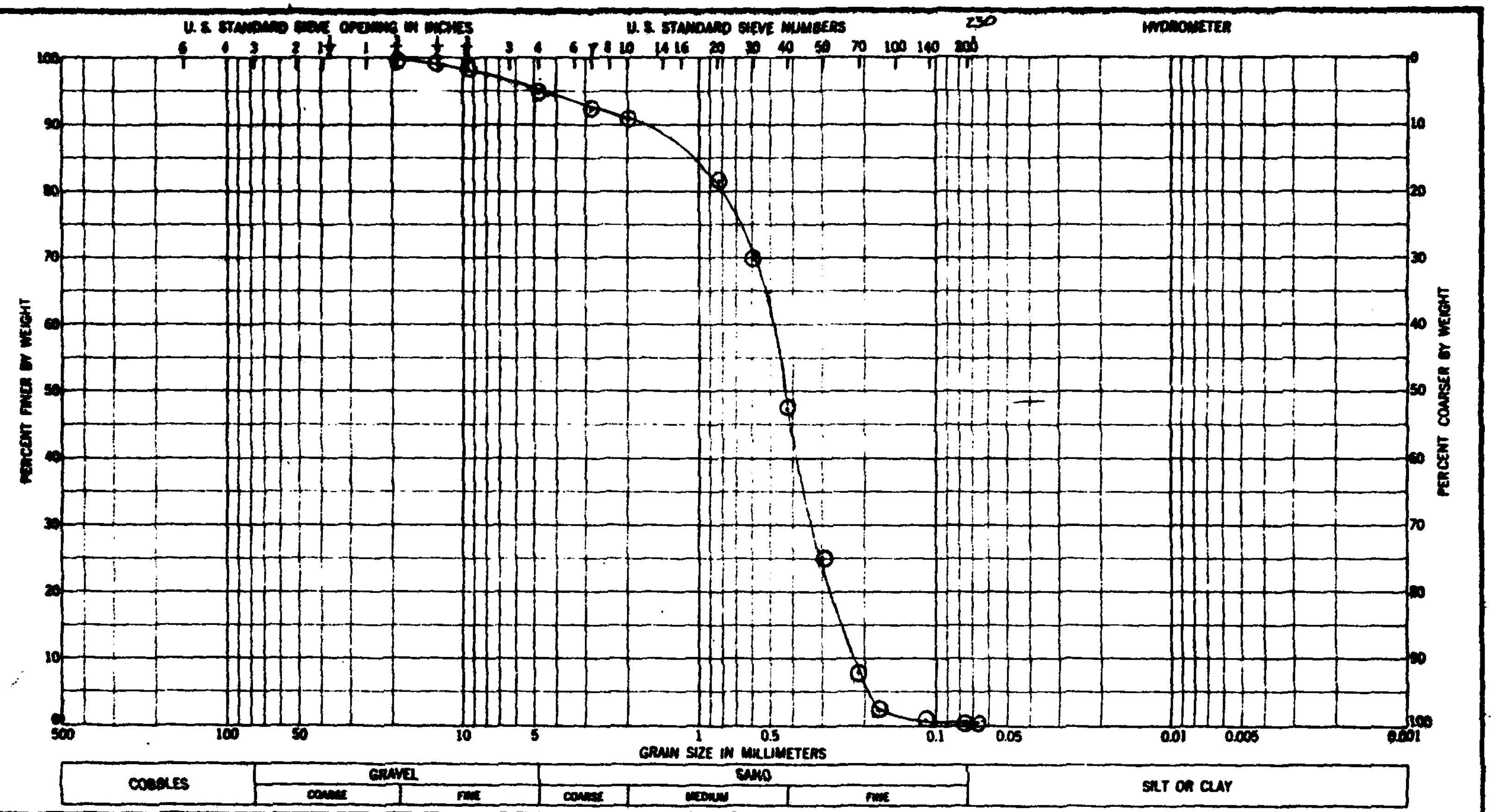


Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI	
Profile 13 18 foot depth	18 foot	Grey brown, silty med. to fine sand (SP-SM) with shell fragments					Project Sherwood Island, Westport, Connecticut Area Profile #13 Lab Ser. #73-314-46 Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-19



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 13 200' from Back of Beach	11.5	Light brown, med. to fine sand (SP) with shell fragments				

Project: Sherwood Island, Westport, Connecticut

Area: Profile #13

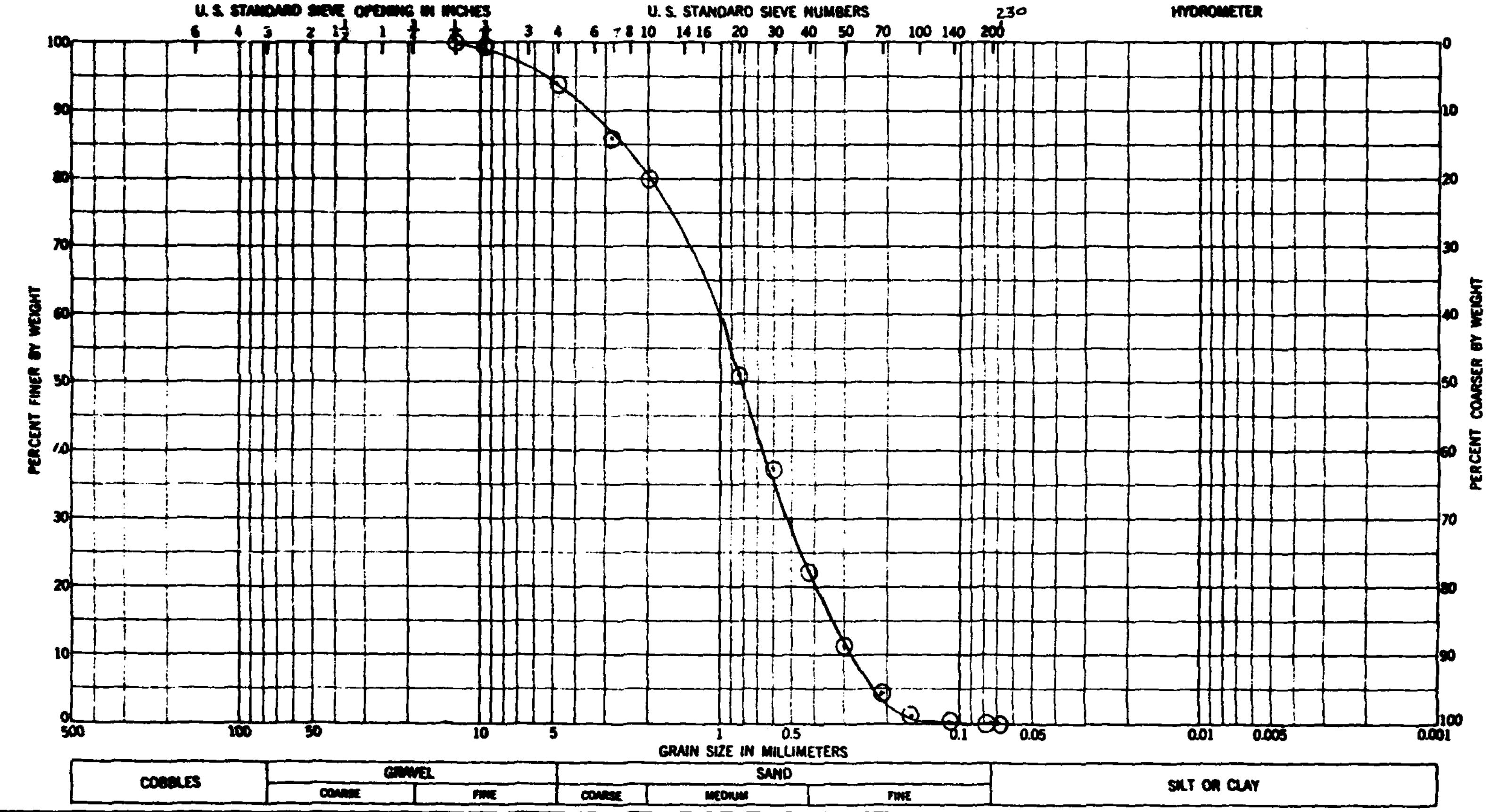
Lab Ser. #73-314-47

Date: January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-20



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 14 50' from Back of Beach	11.0	Light brown, coarse to fine (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

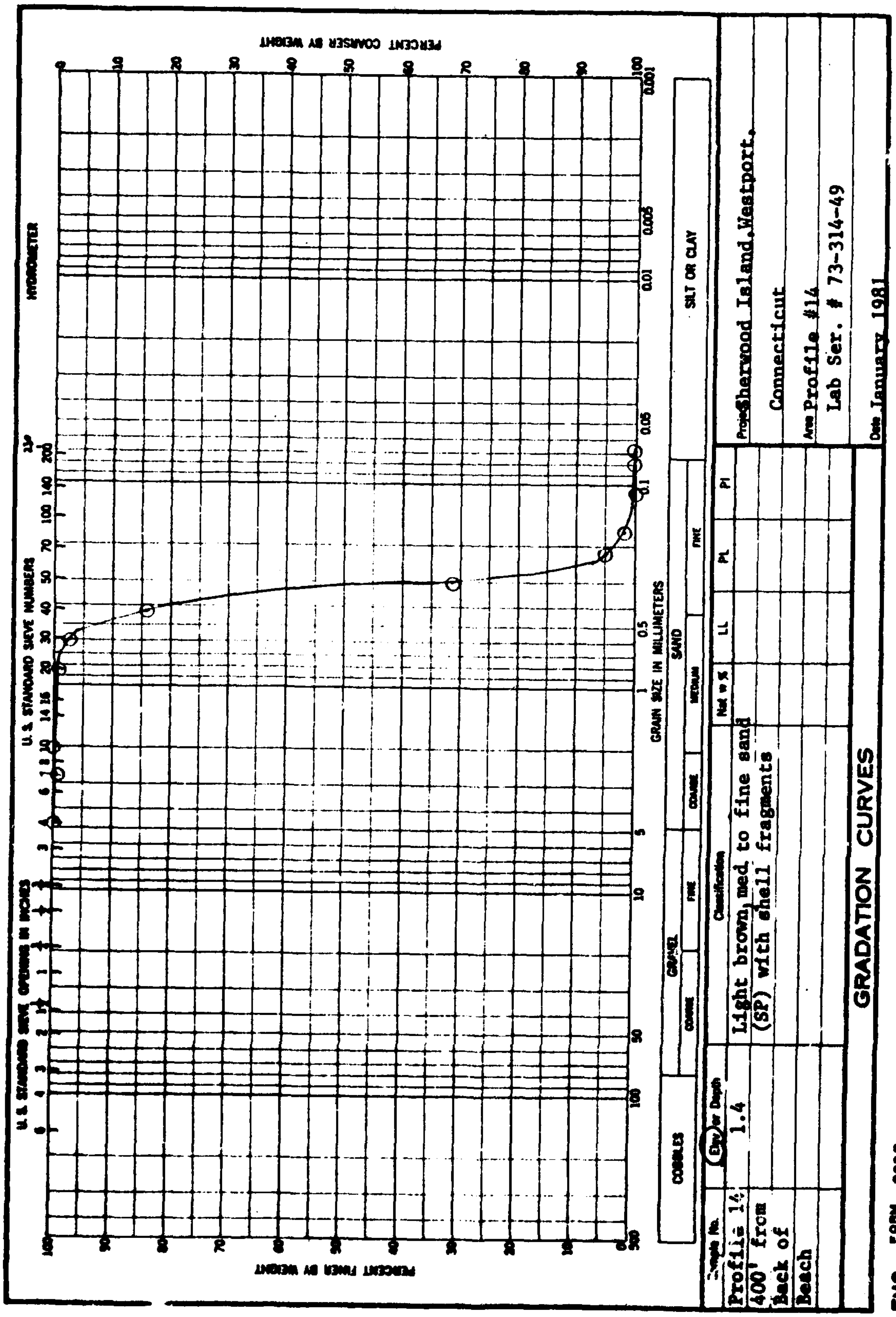
Area Profile #14
Lab Ser. #73-314-48

Date January 1981

GRADATION CURVES

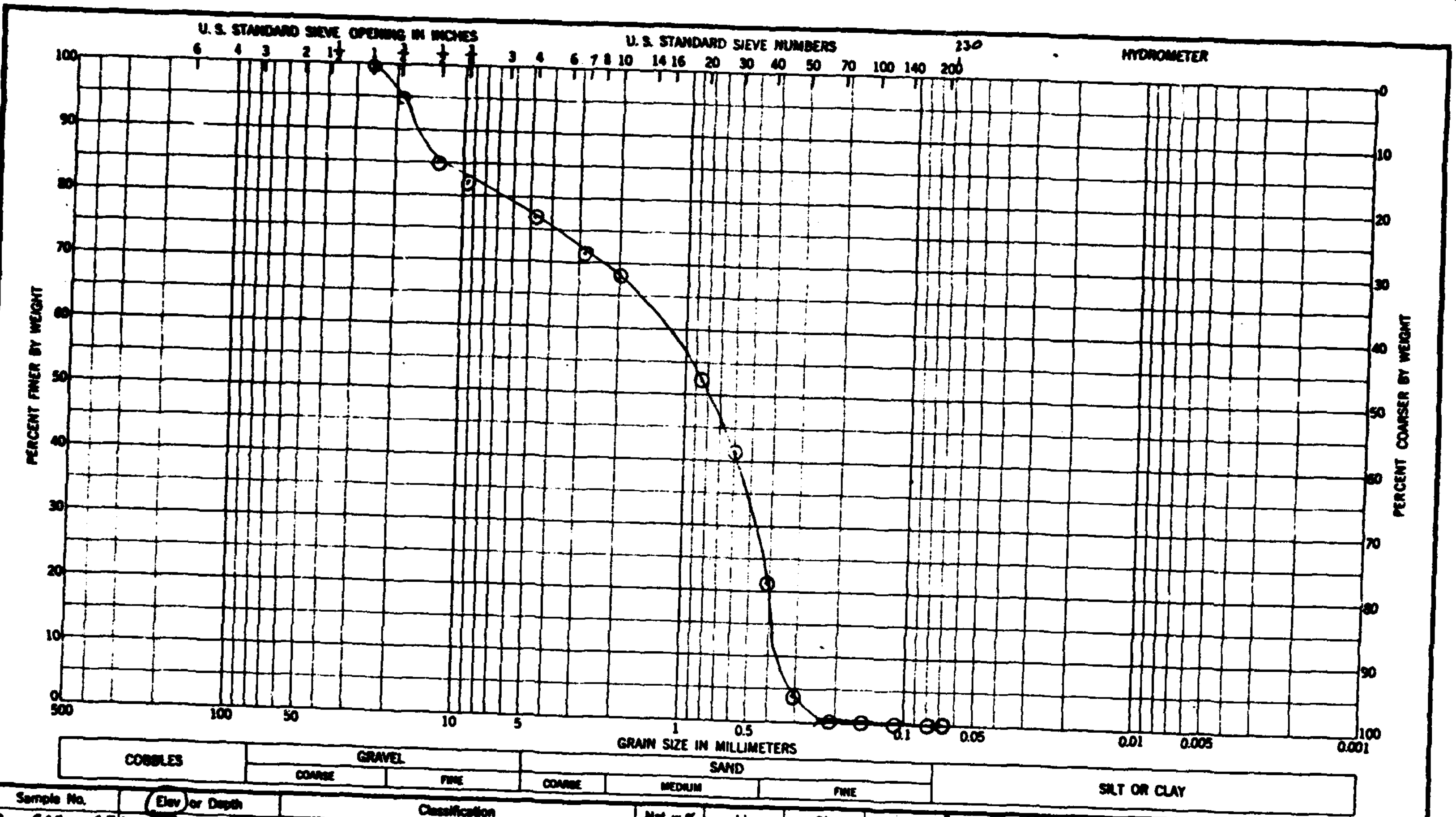
ENG FORM 1 MAY 63 2087

figure 1-21



GRADATION CURVES
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
MEDIUM
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 14
400' from
Back of
Beach
1.4
Light brown, med. to fine sand
(SP) with shell fragments
Project Sherwood Island, Westport,
Connecticut
Area Profile #14
Lab Ser. # 73-314-49
Date January 1981
ENG FORM 1 MAY 63 2087

figure 1-22



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 15A 44' from Back of Beach	9.6	Light brown, gravelly coarse to fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #15A

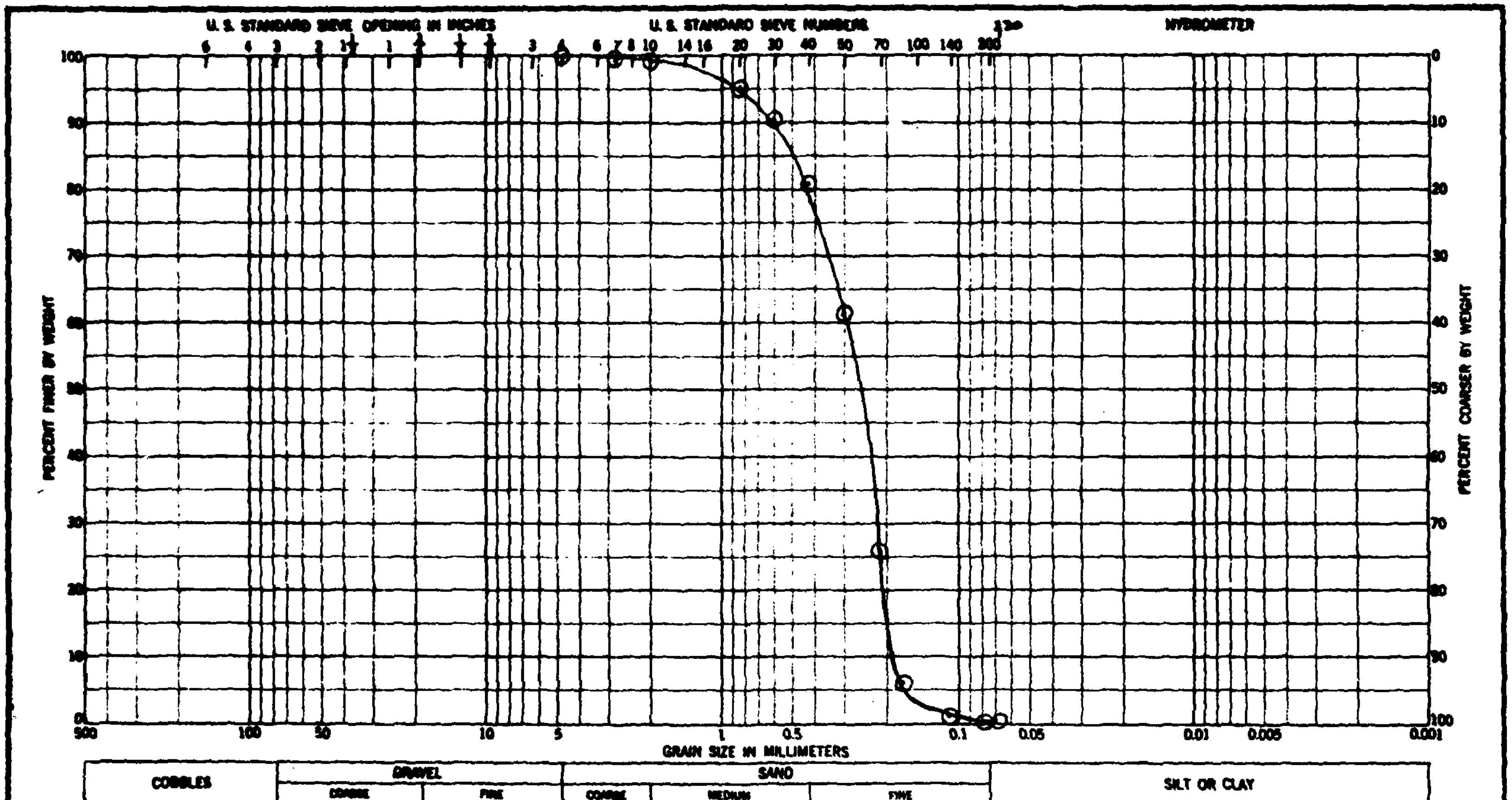
Lab Ser. #73-314-50

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-23



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 15A 300' from Back of Beach	0.5	Light brown med. to fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #15A

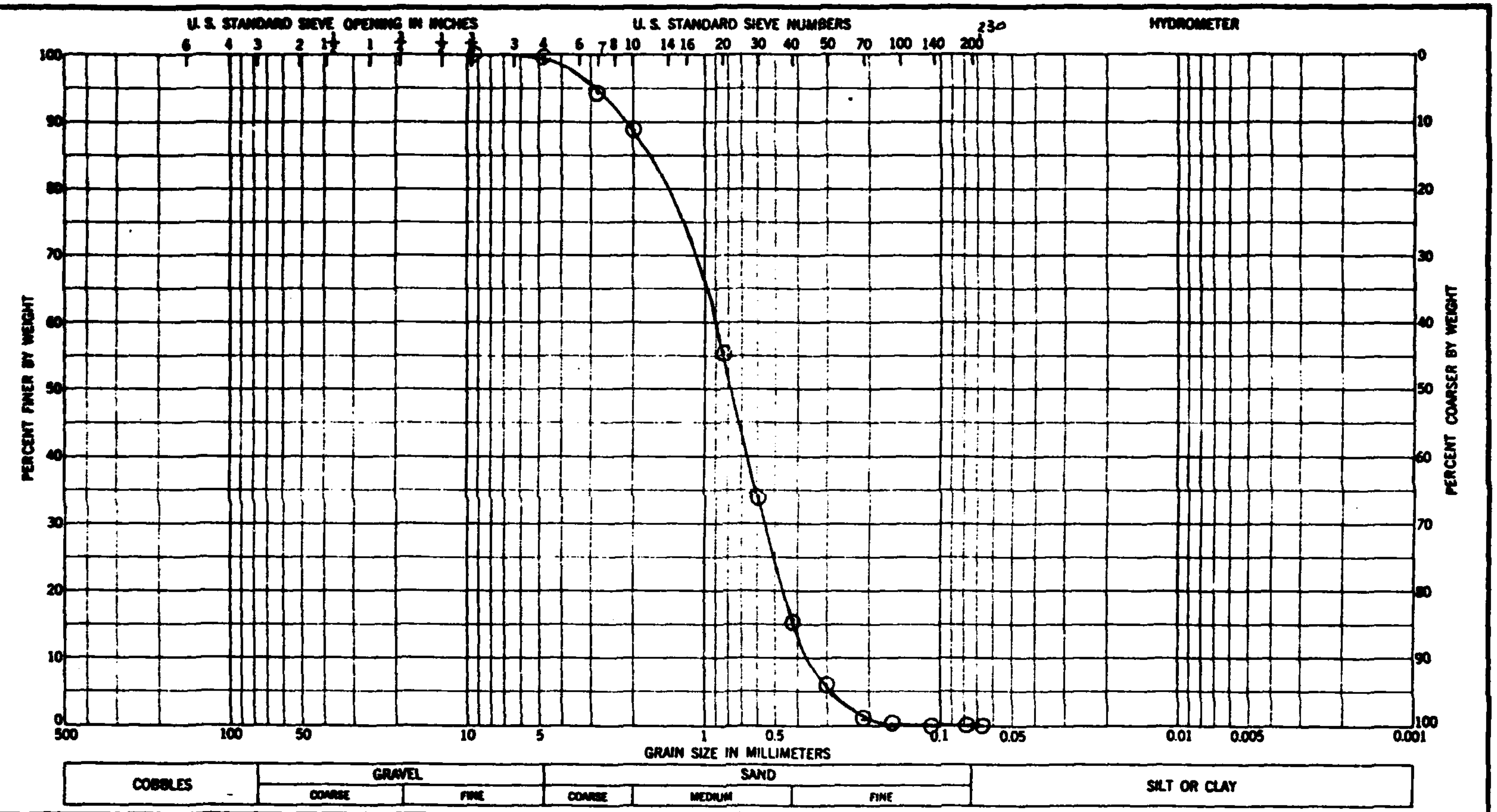
Lab Ser. #73-314-51

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-24



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 17	12.2	Light brown, coarse to fine				
20' from		sand (SP) with shell frags.				
Back of						
Beach						

Project Sherwood Island, Westport,
Connecticut

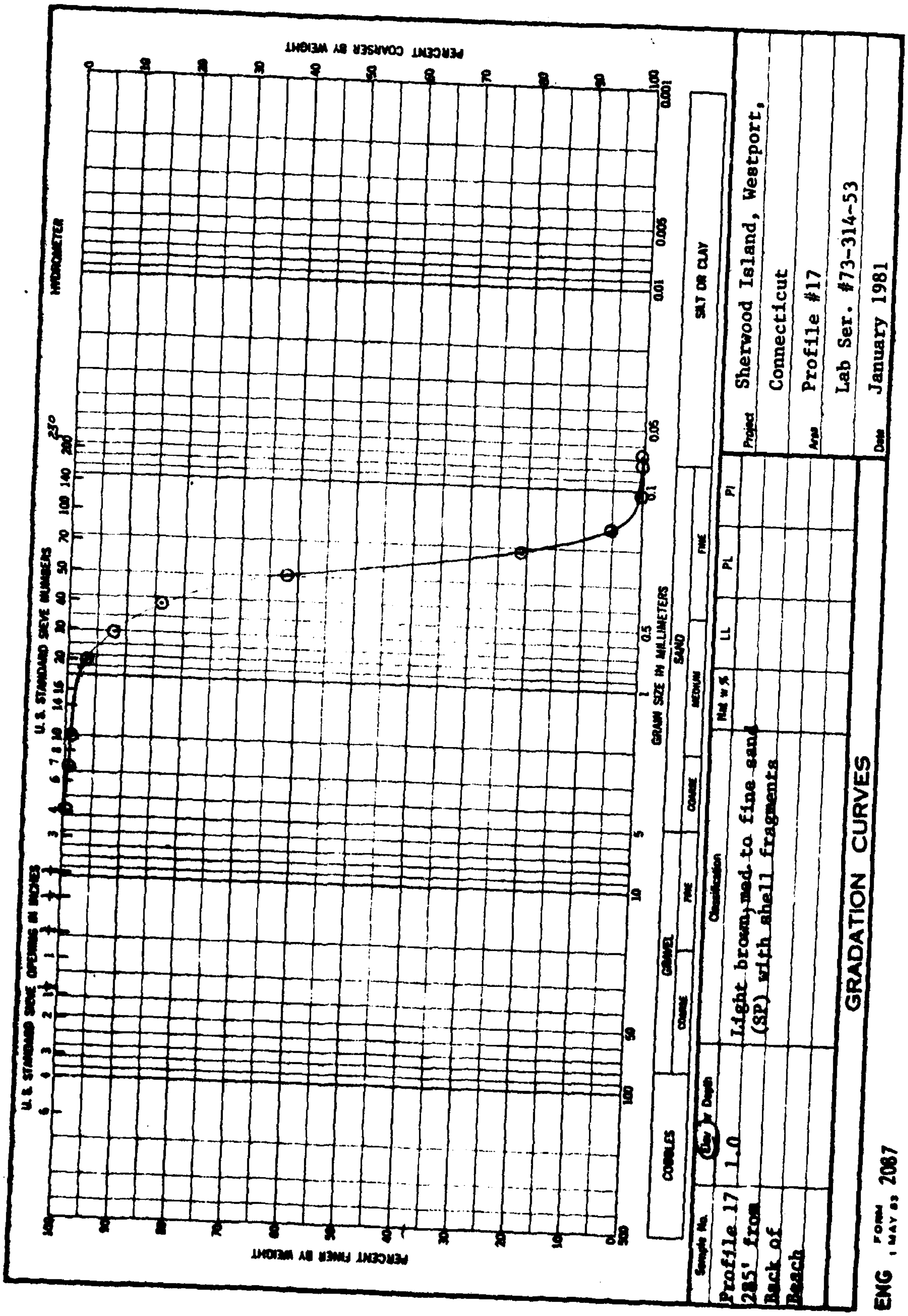
Area Profile #17
Lab Ser. #73-314-52

Date January 1981

GRADATION CURVES

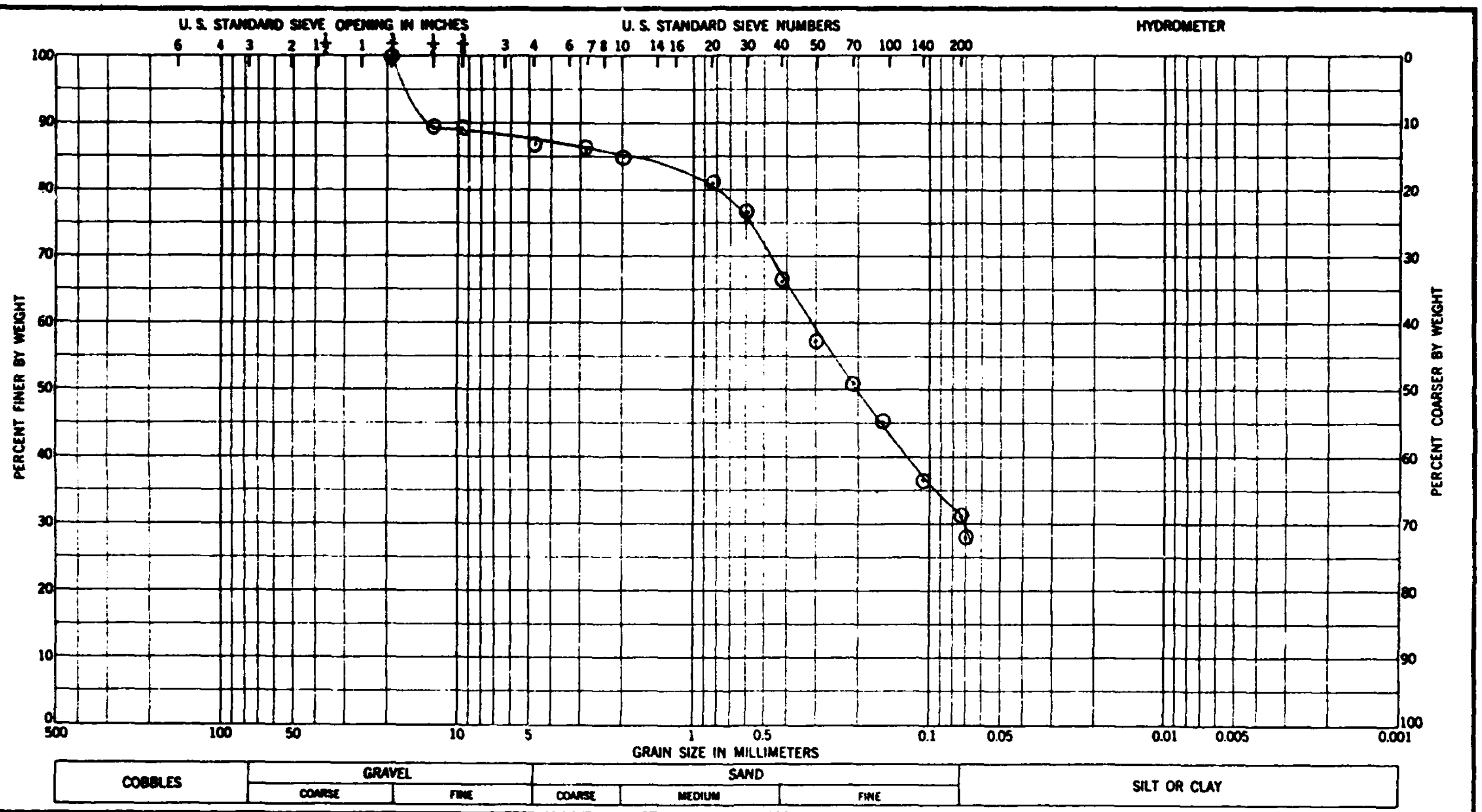
ENG FORM 1 MAY 63 2087

figure 1-25



PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 17
285' from
Back of
Beach
1.0
Light brown, med to fine sand
(SP) with shell fragments
Project
Sherwood Island, Westport,
Connecticut
Area
Profile #17
Lab Ser. #73-314-53
Date
January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-26



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 17 6 foot depth	6 foot	Grey brown, gravelly clay with sand (SC) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #17

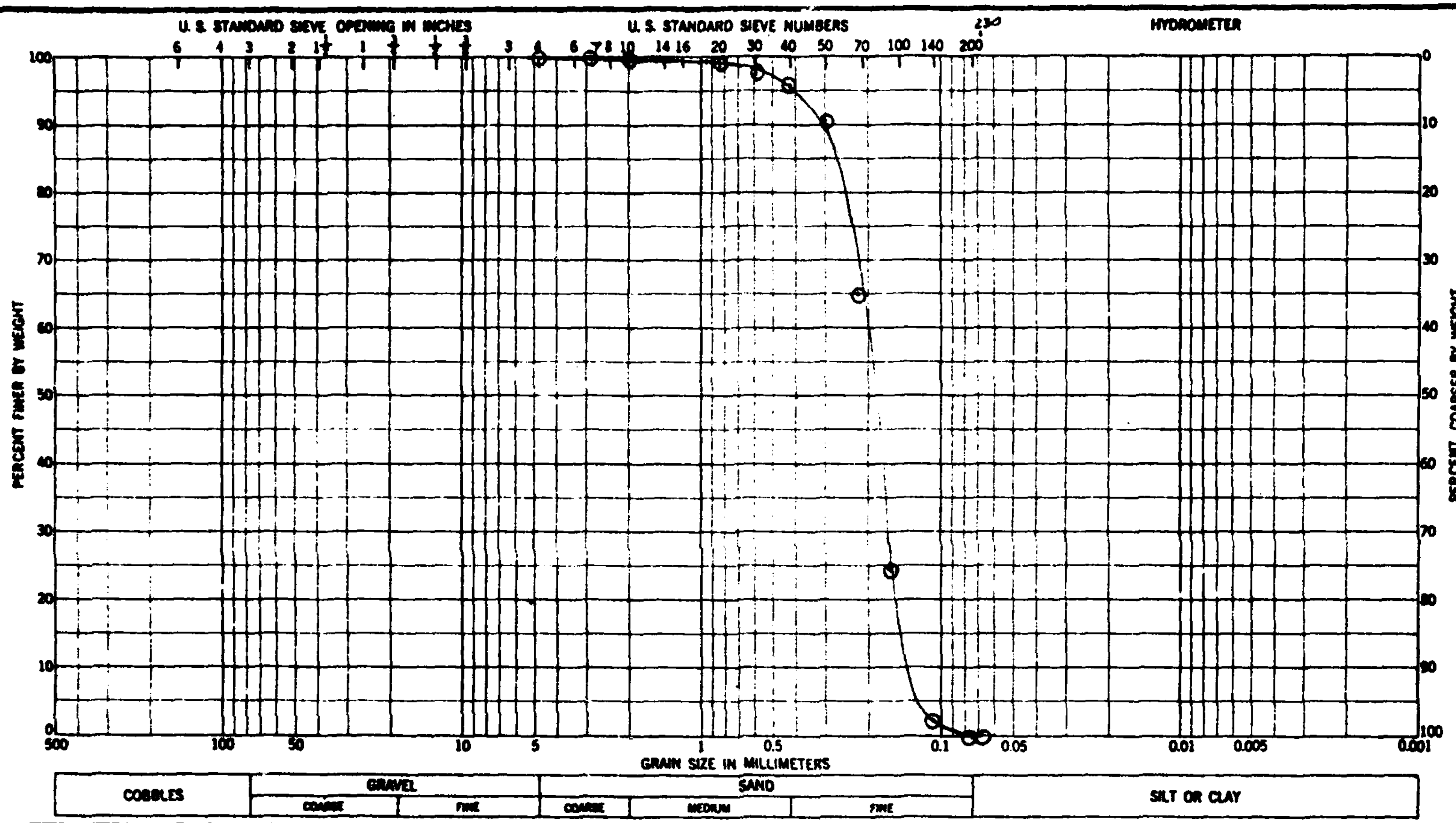
Lab Ser. #73-314-54

Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-27



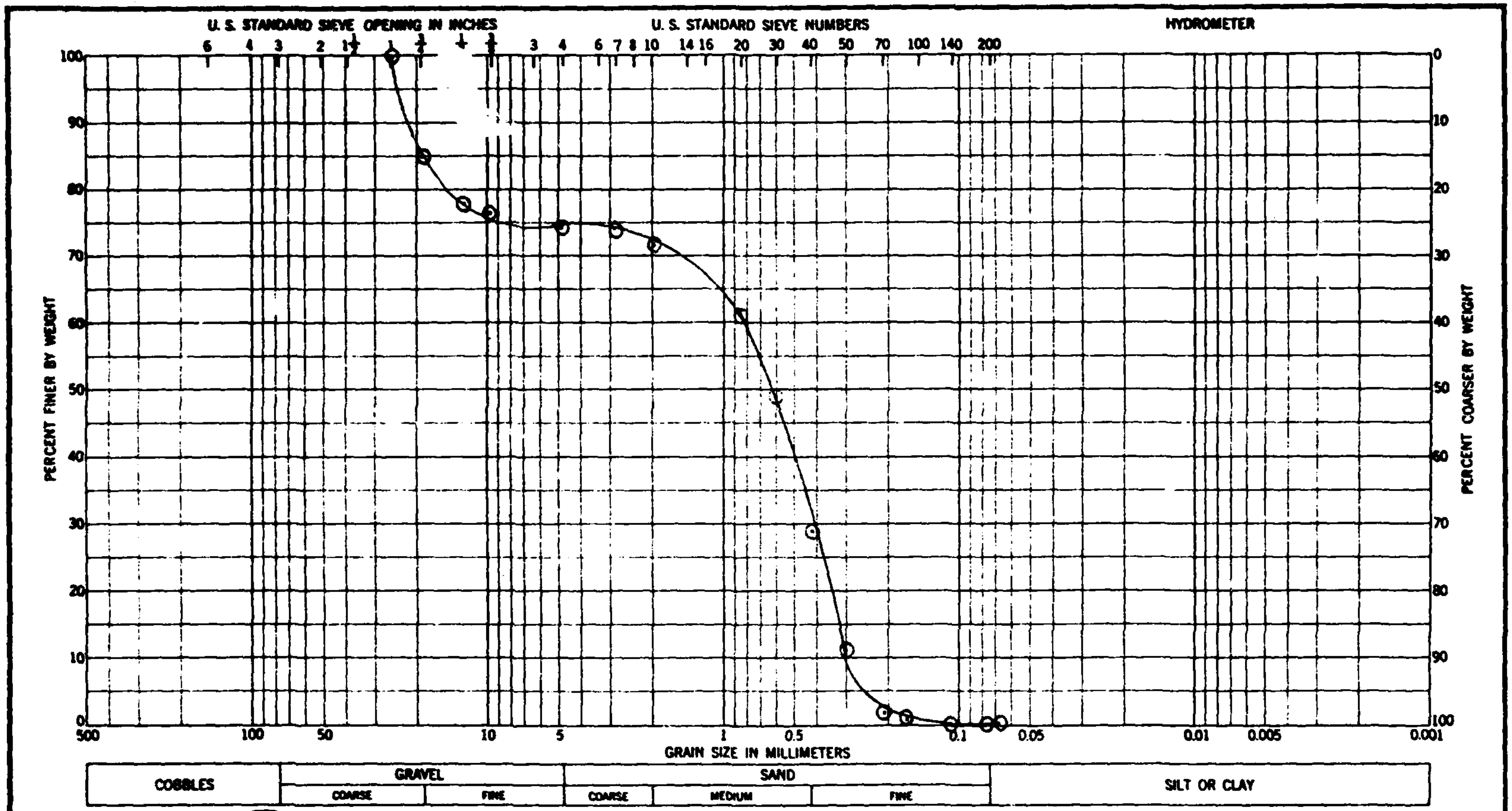
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 17 12 foot depth	12 foot	Grey brown, fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut
Area Profile #17
Lab Ser. #73-314-55
Date January 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087

figure 1-28



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 17 18 foot depth	18 foot	Grey brown, gravelly med. to fine sand (SP) with shell fragments				

Project: Sherwood Island, Westport, Connecticut

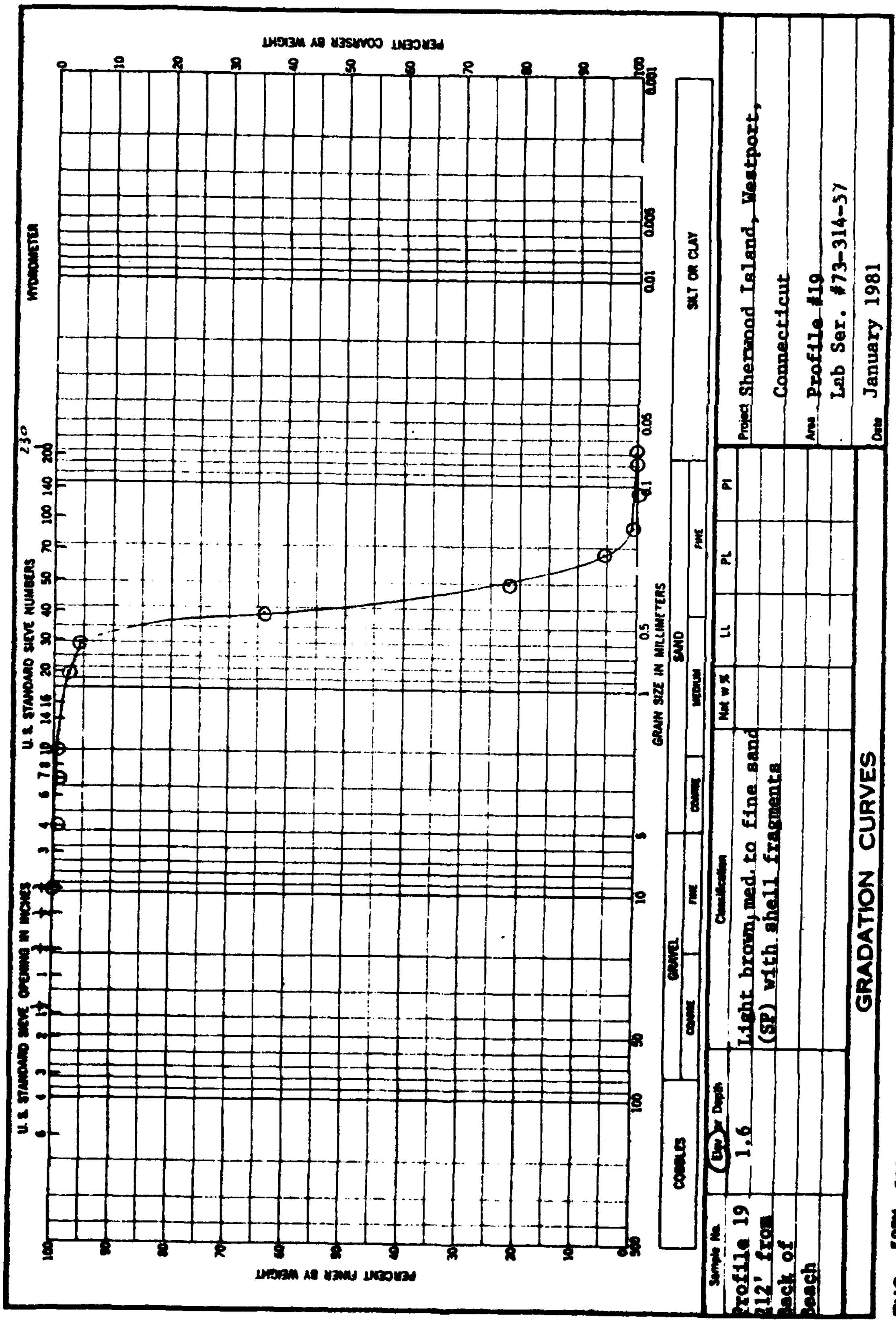
Area: Profile #17
Lab Ser. #73-314-56

Date: January 1981

GRADATION CURVES

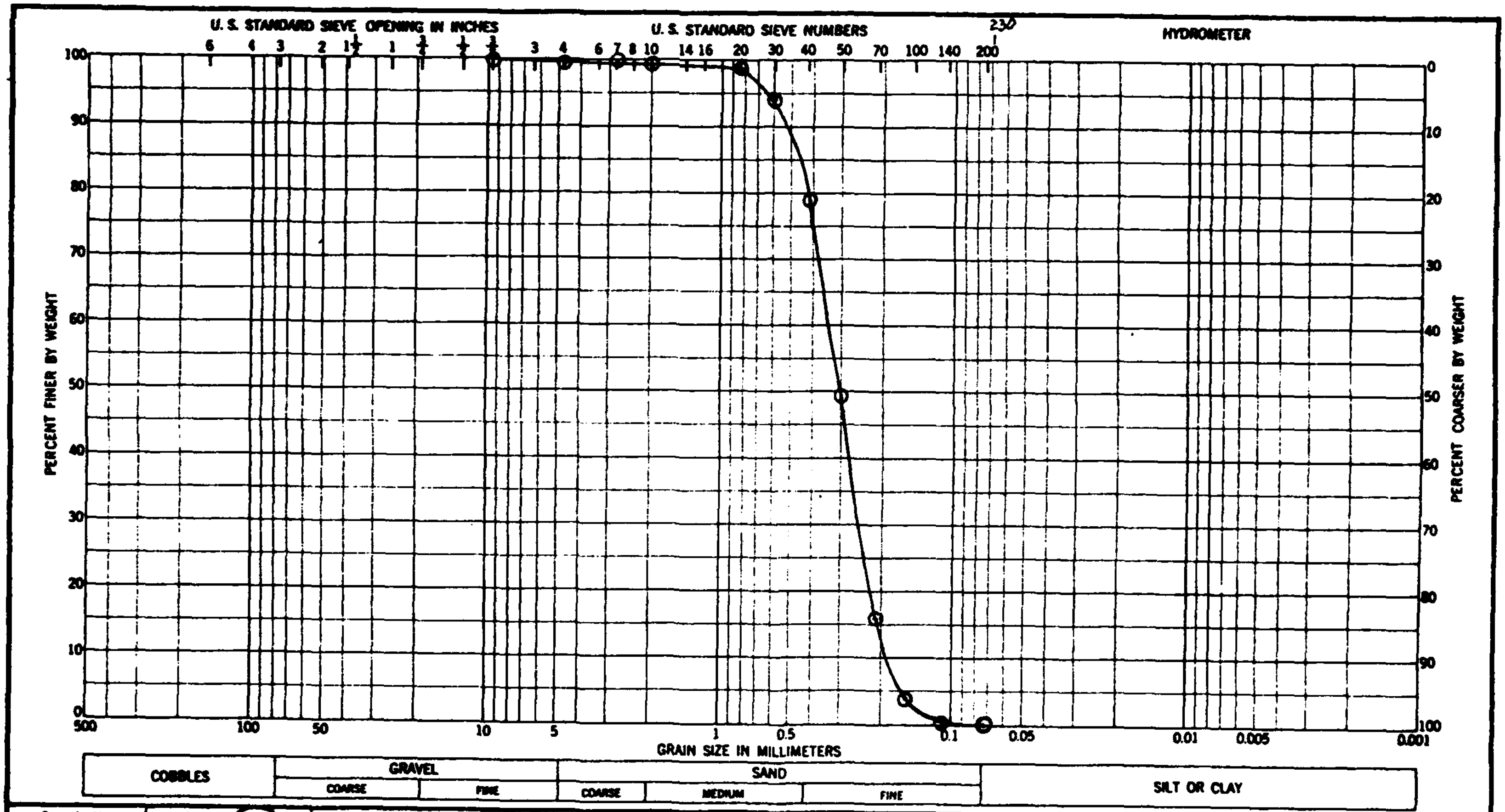
ENG FORM 1 MAY 63 2087

figure 1-29



GRADATION CURVES
Project Sherwood Island, Westport, Connecticut
Area Profile #19
Lab Ser. #73-314-57
Date January 1981
Sample No. Profile 19 212' from Back of Beach
Elev or Depth 1.6
Classification Light brown, med. to fine sand (SP) with shell fragments
Nat w % LL PL PI
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
ENG FORM 1 MAY 63 2087

figure 1-30



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Profile 19 6 foot depth	6 foot	Grey brown, med. to fine sand (SP) with shell fragments				

Project Sherwood Island, Westport, Connecticut

Area Profile #19

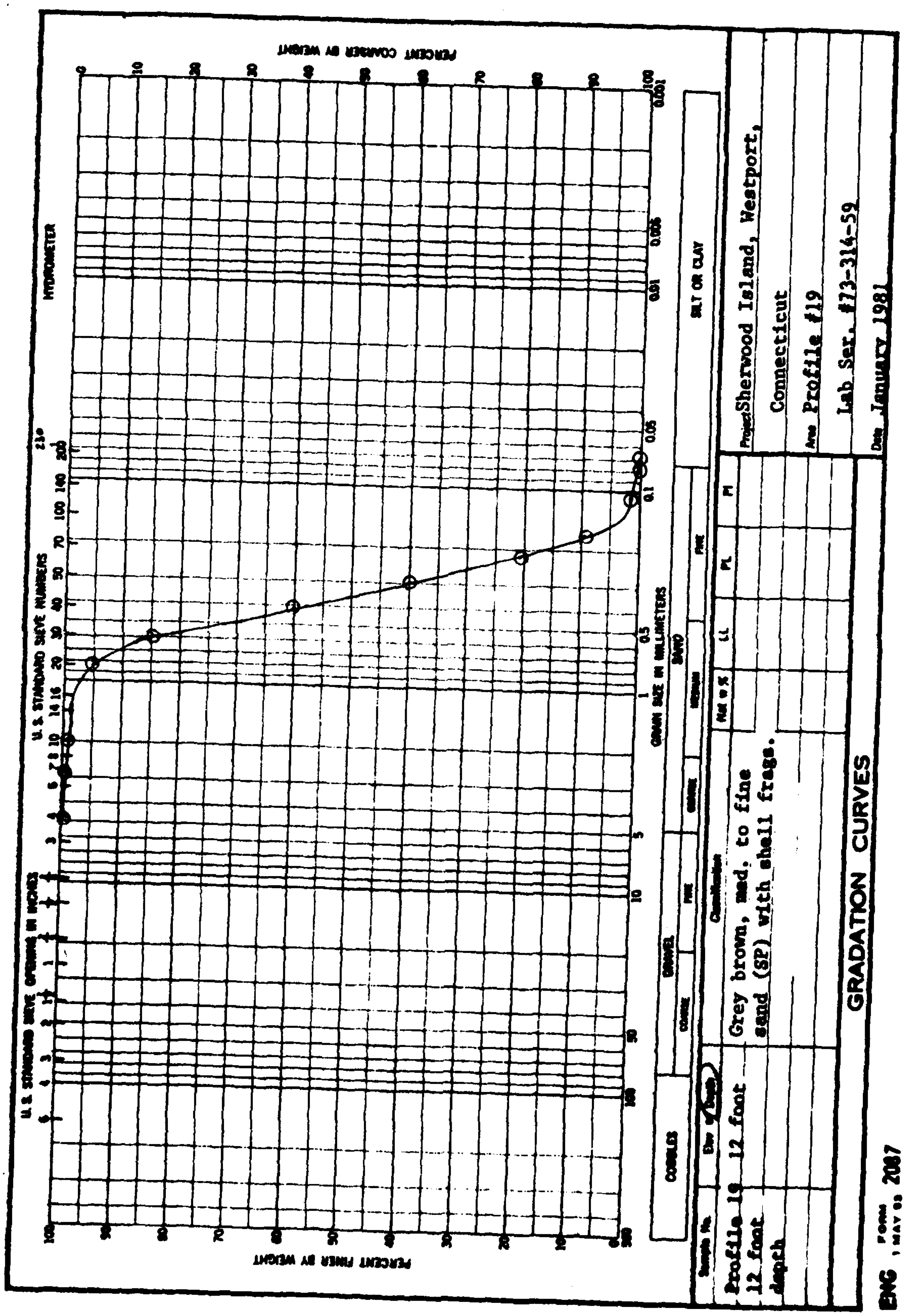
Lab Ser. #73-314-58

Date January 1981

GRADATION CURVES

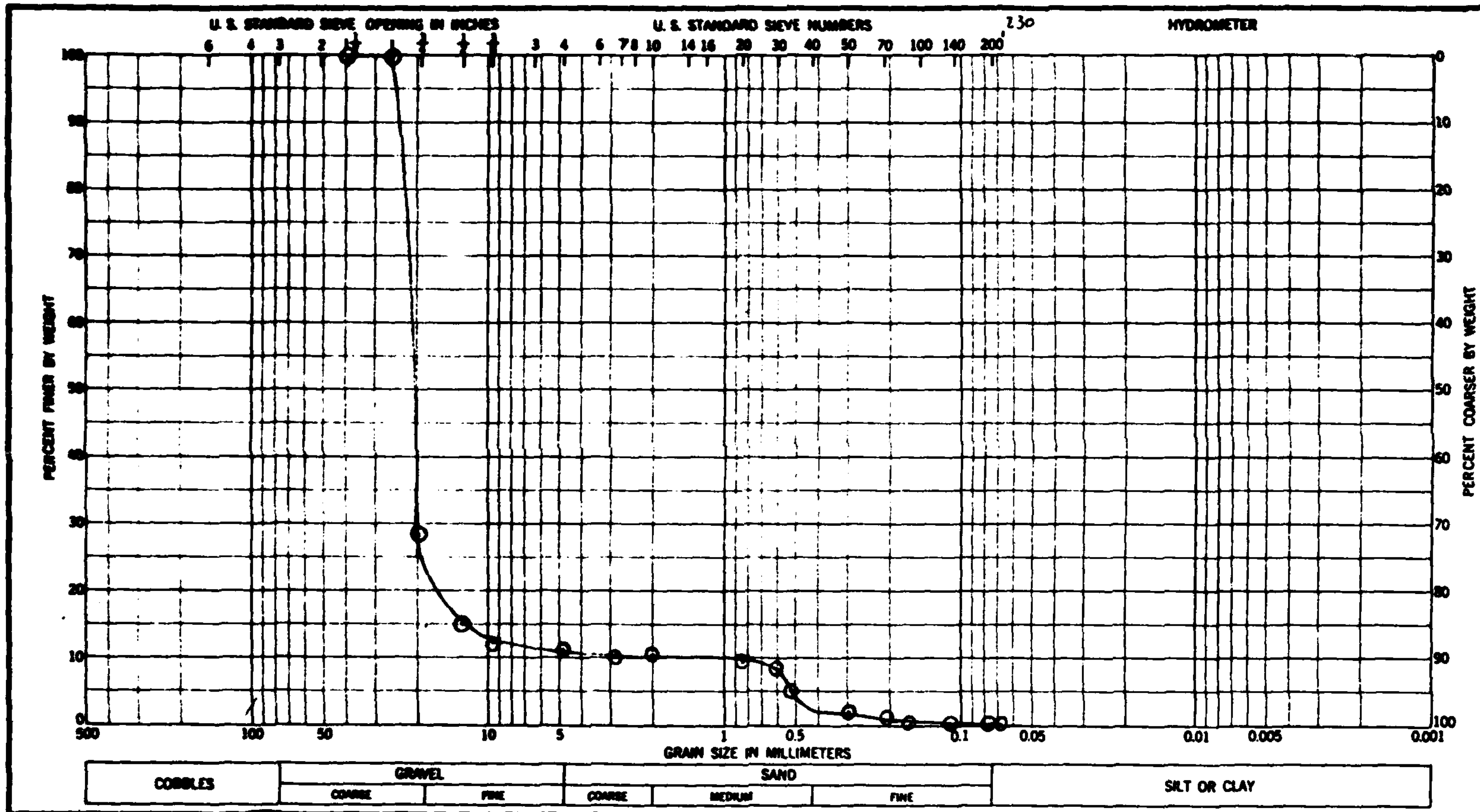
ENG FORM 1 MAY 63 2087

figure 1-31



PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
Profile 19
12 foot depth
Grey brown, med. to fine sand (SP) with shell frags.
Project Sherwood Island, Westport, Connecticut
Area Profile #19
Lab Ser. #73-316-59
Date January 1981
GRADATION CURVES
ENG FORM 1 MAY 63 2087

figure 1-32



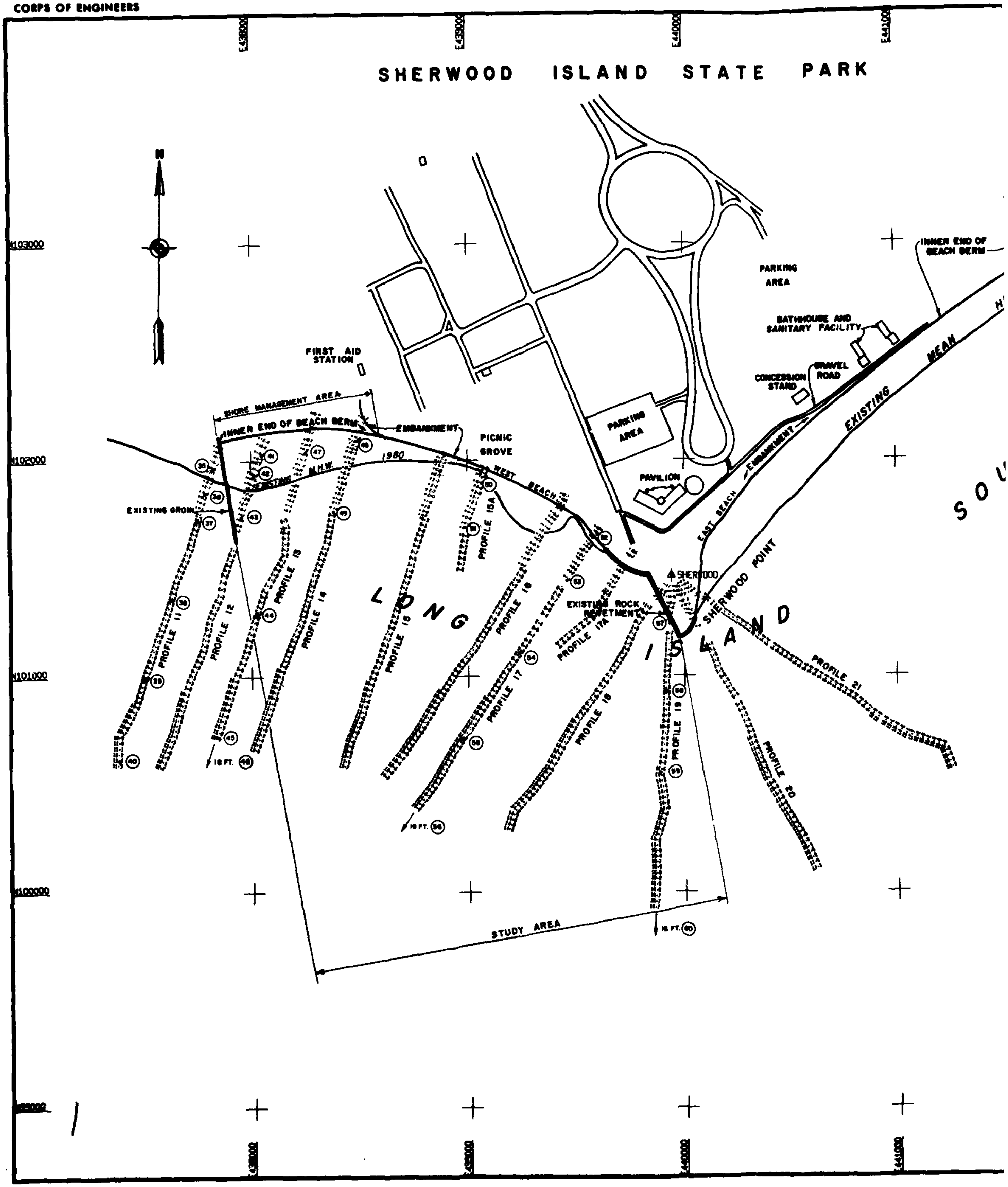
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI	
Profile 19 18 foot depth	18 foot	Grey brown, sandy gravel (GP) with shell fragments					Project Sherwood Island, Westport, Connecticut Area Profile #19 Lab Ser. #73-314-60 Date January 1981

GRADATION CURVES

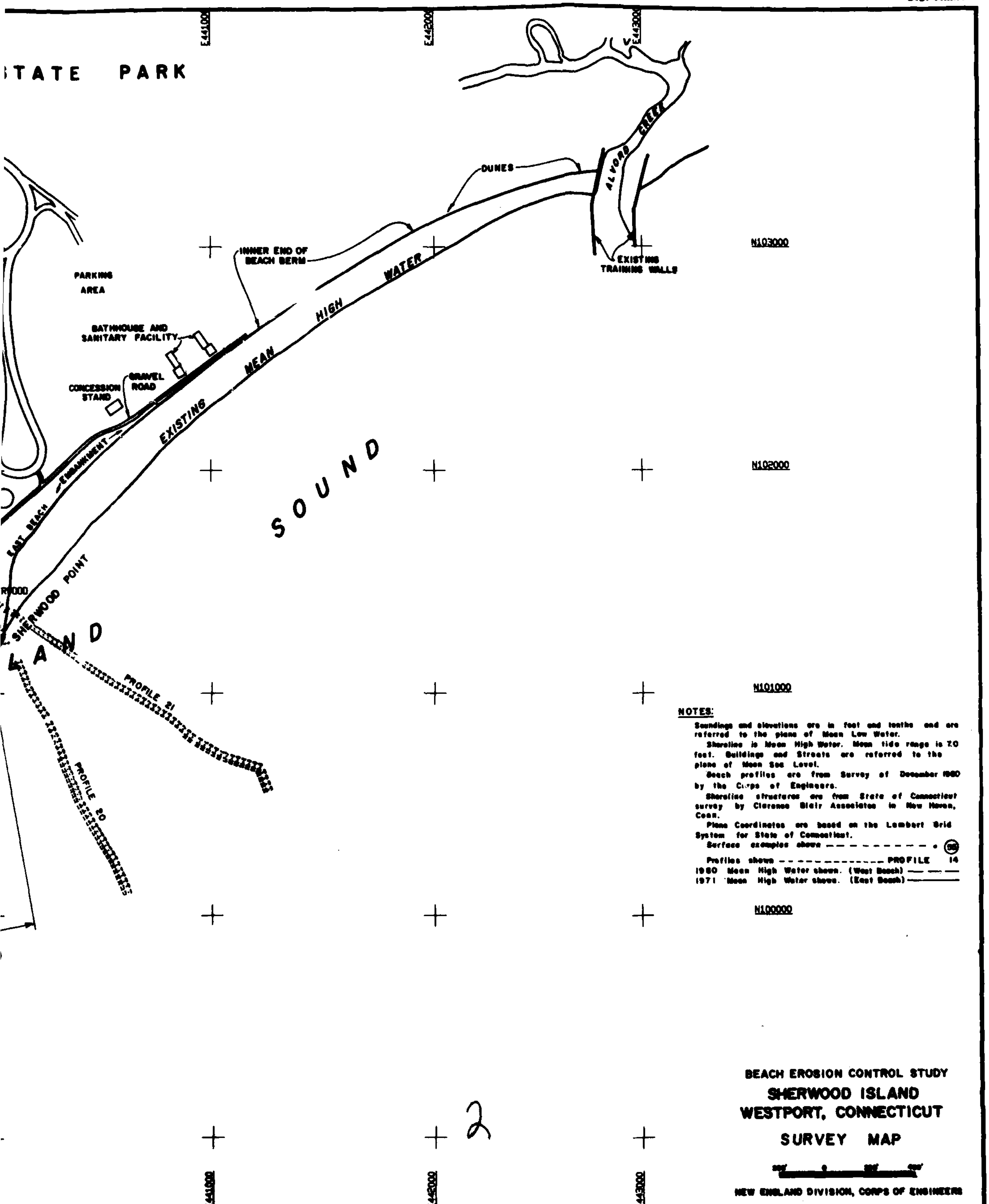
ENG FORM 1 MAY 63 2087

figure 1-33

CORPS OF ENGINEERS



SHERWOOD ISLAND



NOTES:

Soundings and elevations are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Mean tide range is 7.0 feet. Buildings and Streets are referred to the plane of Mean Sea Level.

Beach profiles are from Survey of December 1980 by the Corps of Engineers.

Shoreline structures are from State of Connecticut survey by Clarence Blair Associates in New Haven, Conn.

Plane Coordinates are based on the Lambert Grid System for State of Connecticut.

Surface examples shown

Profiles shown — PROFILE 14

1980 Mean High Water shown. (West Beach)

1971 Mean High Water shown. (East Beach)

BEACH EROSION CONTROL STUDY

SHERWOOD ISLAND

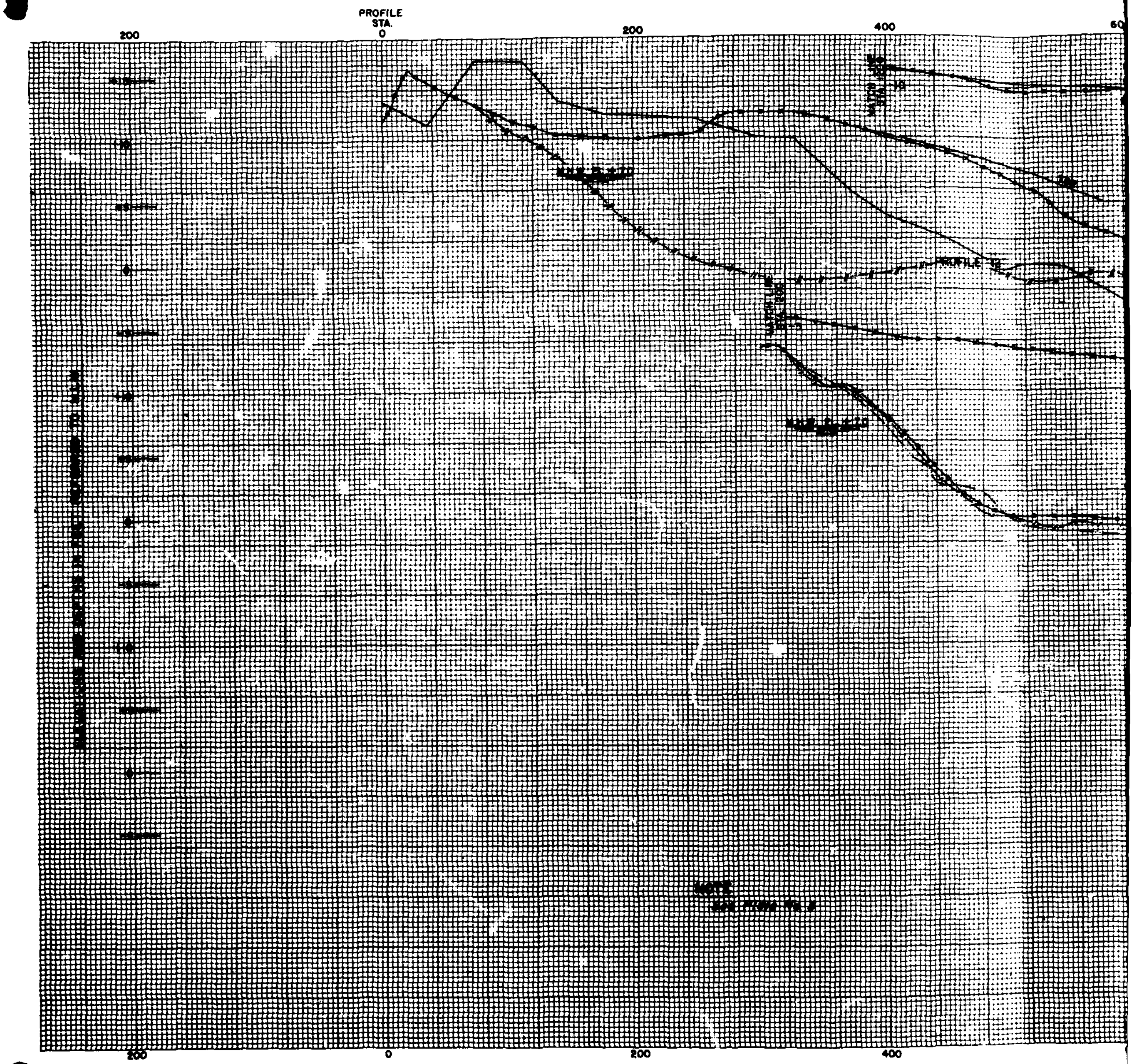
WESTPORT, CONNECTICUT

SURVEY MAP

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

2

PLATE 1-1


PROFILE
STA.
0
200
400

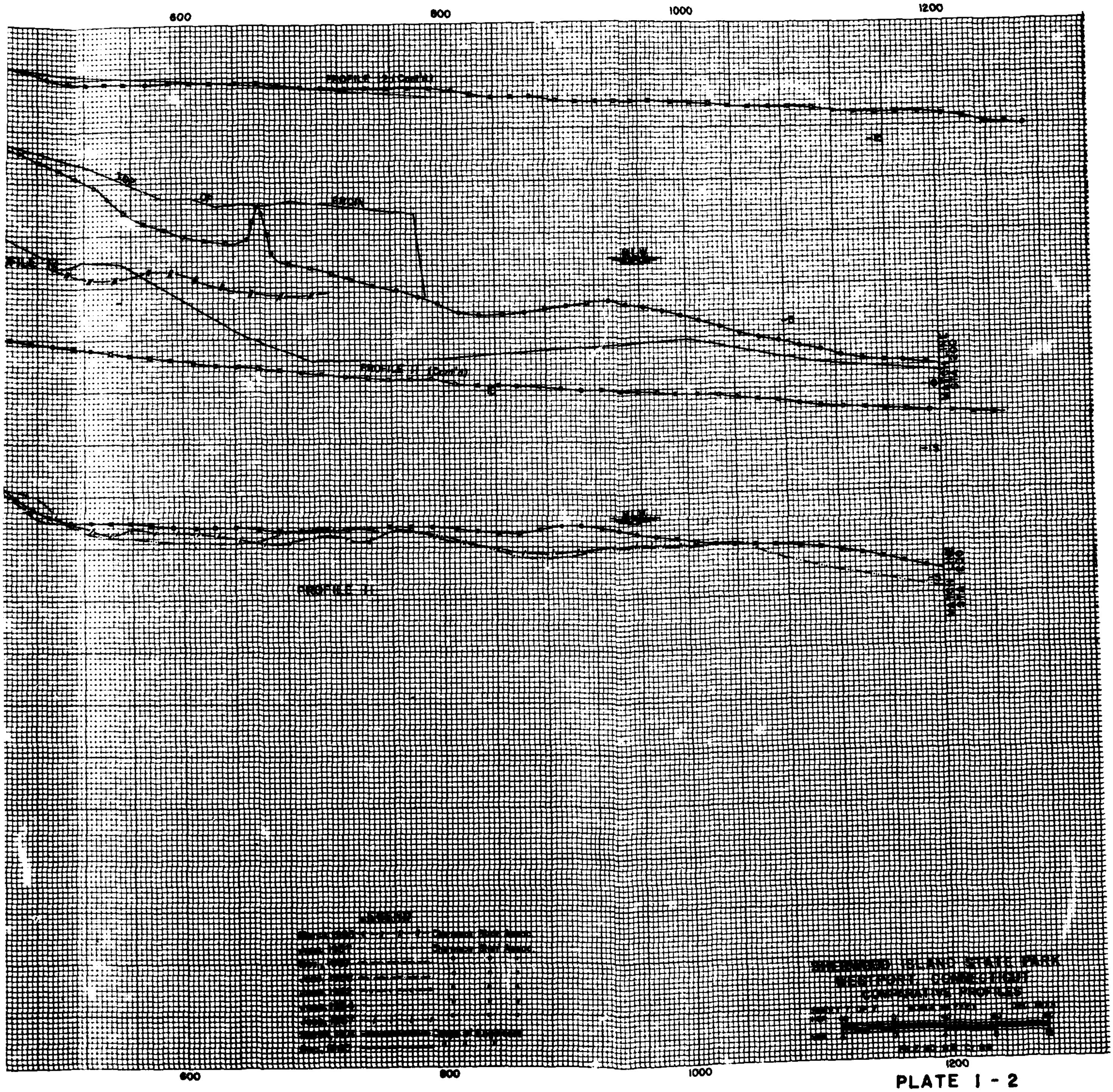
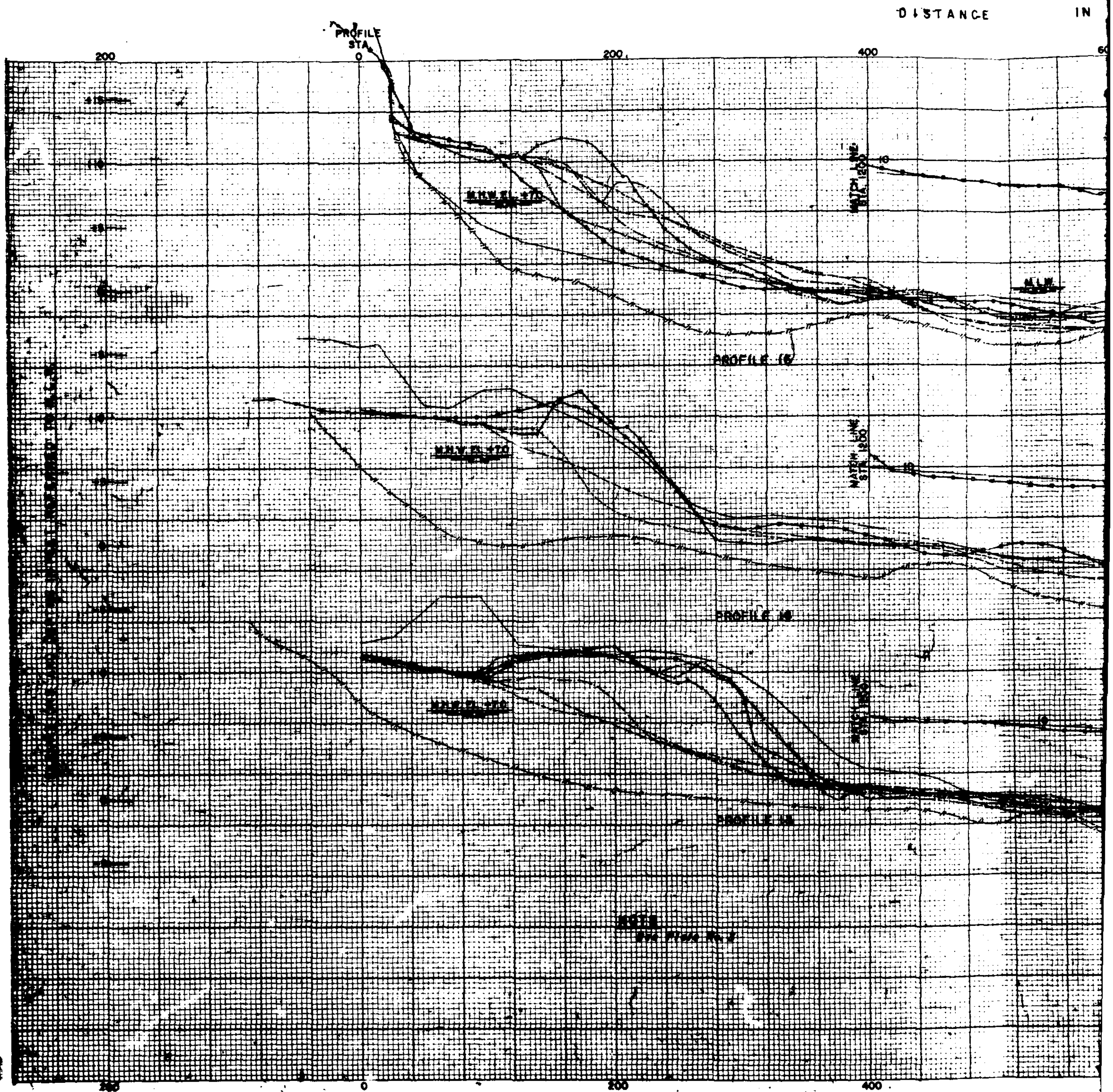

600
800
1000
1200
PROFILE 11 (Cont'd)
PROFILE 11
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
COMPARATIVE PROFILES

PLATE I - 2

2


DISTANCE IN
PROFILE STA. 0
200
0
200
400
M.H.W. EL +7.0
MATCH LINE STA. 1200
M.L.W.
PROFILE 16
PROFILE 18
NOTE

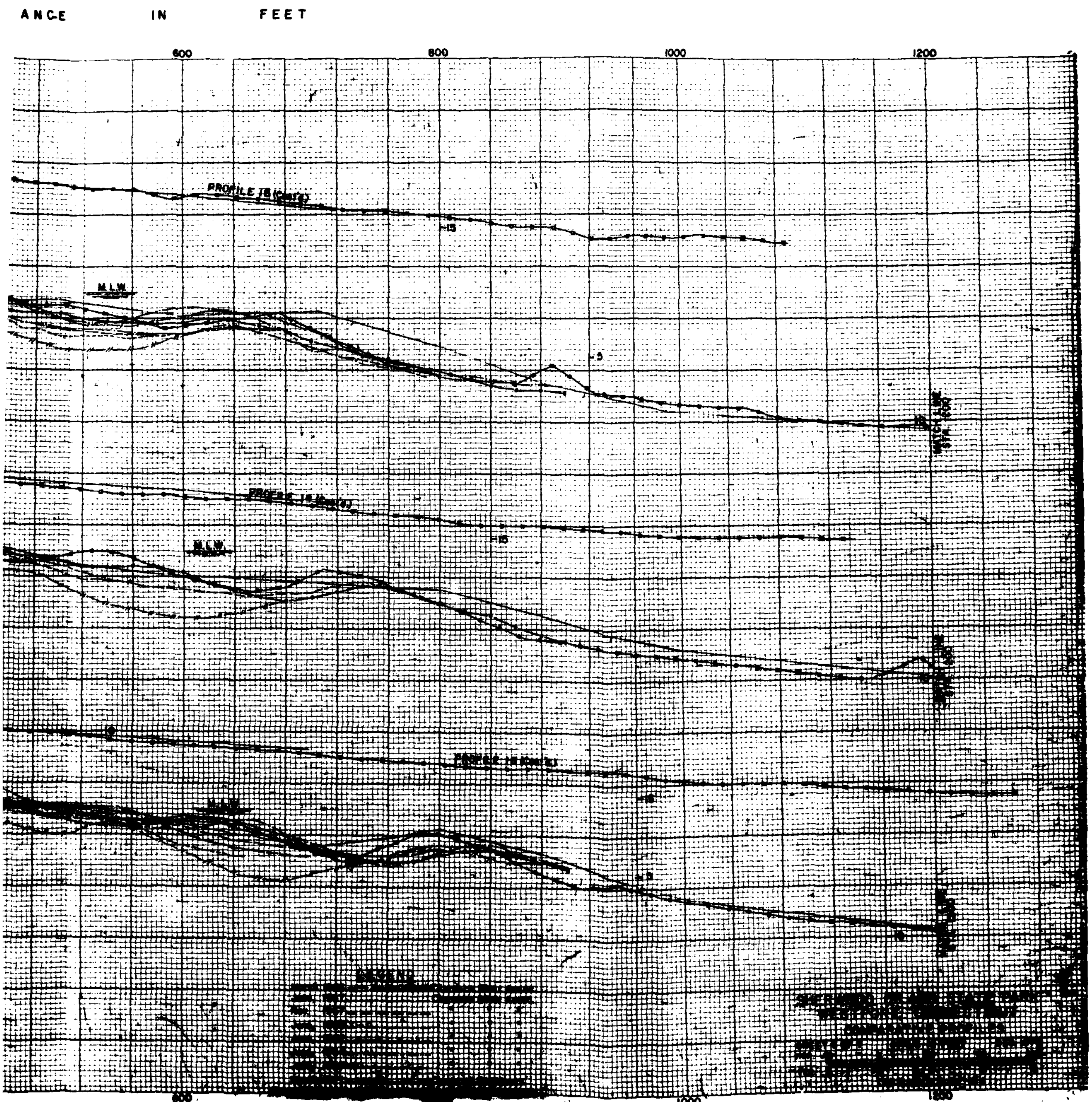
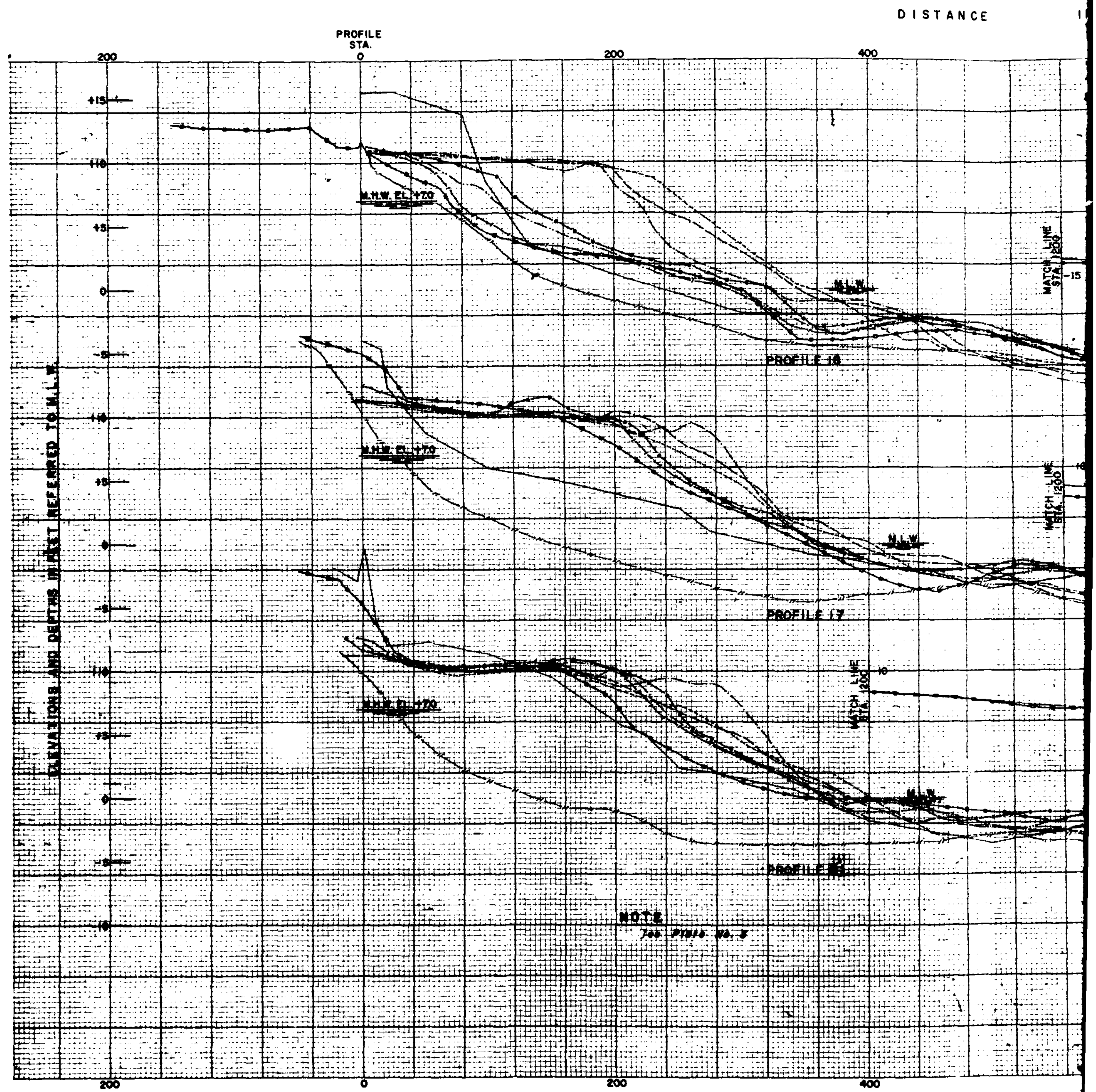

ANCE IN FEET
600
800
1000
1200
PROFILE 18 (Cont'd)
-15
M.L.W.
-5
PROFILE 18 (Cont'd)
-15
M.L.W.
PROFILE 18 (Cont'd)
M.L.W.
600
1000
1200

PLATE I s 3

2


DISTANCE
PROFILE STA.
200
0
200
400
ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.
+15
+10
+5
0
-5
M.H.W. EL. +7.0
M.L.W.
MATCH LINE STA. 1200
PROFILE 18
PROFILE 17
NOTE
See Plate No. 3

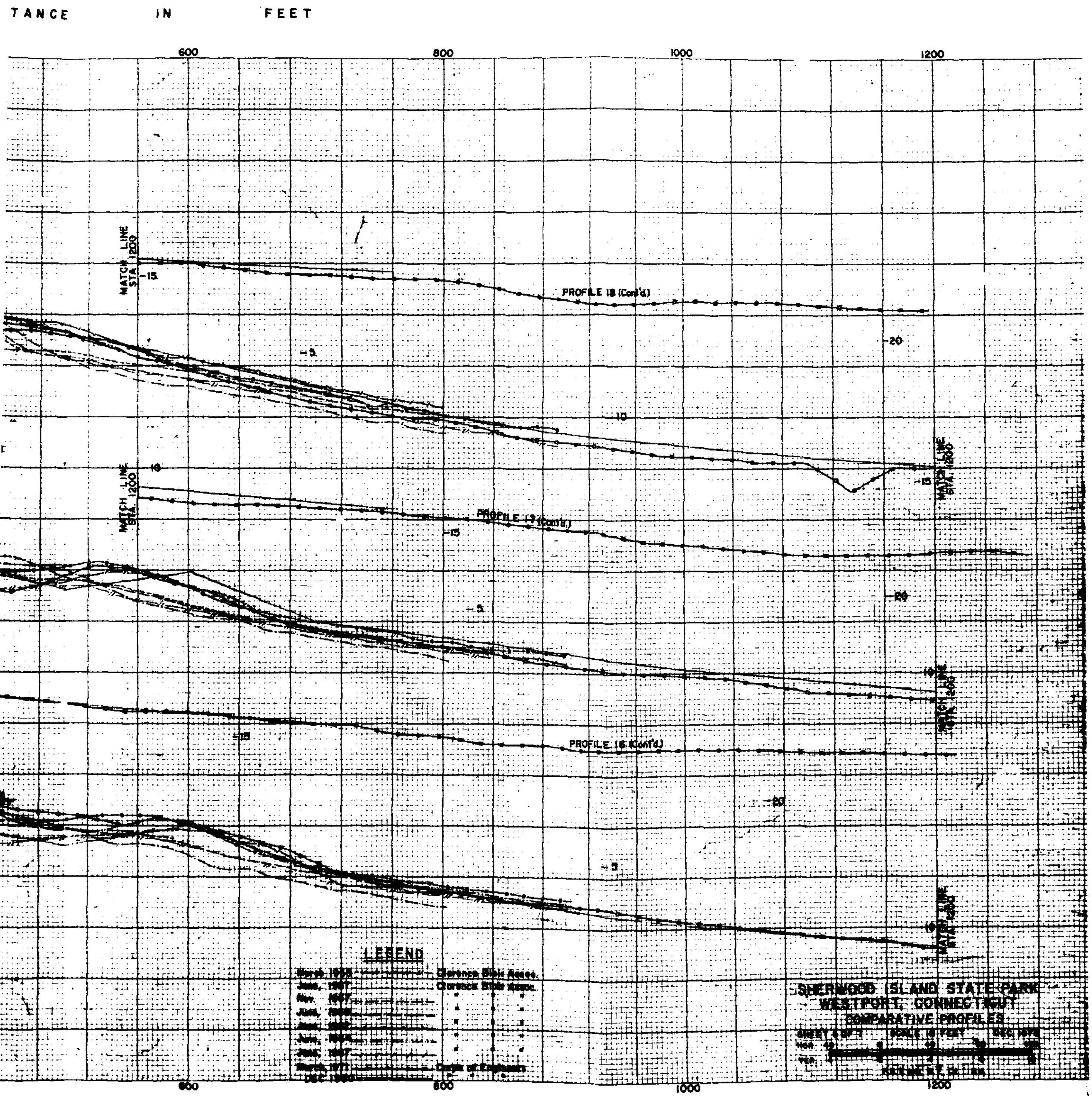
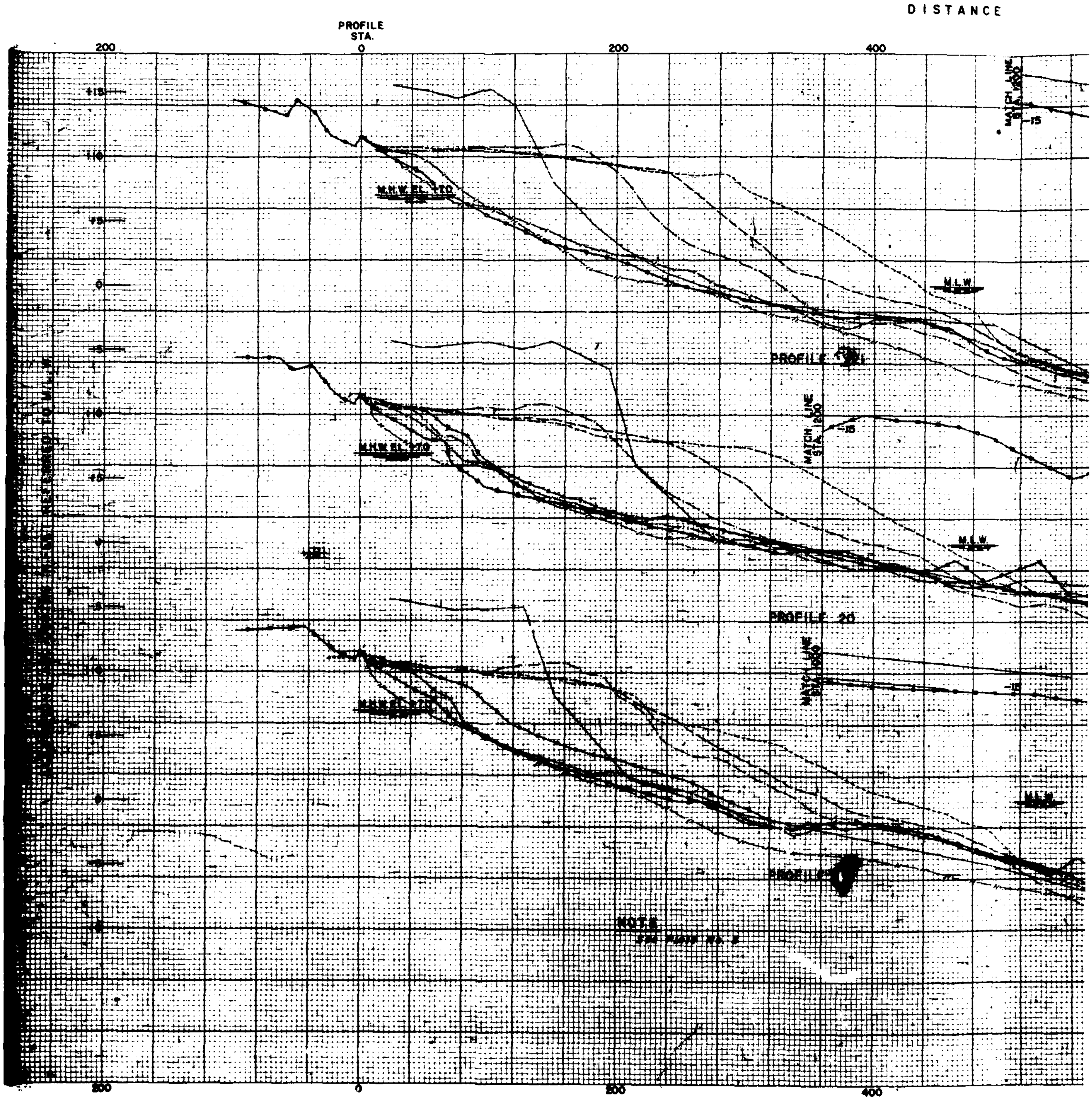

TANCE IN FEET
600
800
1000
1200
MATCH LINE STA. 1200
PROFILE 18 (Cont'd.)
PROFILE 17 (Cont'd.)
PROFILE 16 (Cont'd.)
LEGEND
Clarence Blair Assoc.
Corps of Engineers
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
COMPARATIVE PROFILES

PLATE I - 4


DISTANCE
PROFILE STA.
0
200
400
+15
+10
+5
0
MATCH LINE STA. 1200
-15
M.L.W.
PROFILE 20
NOTE

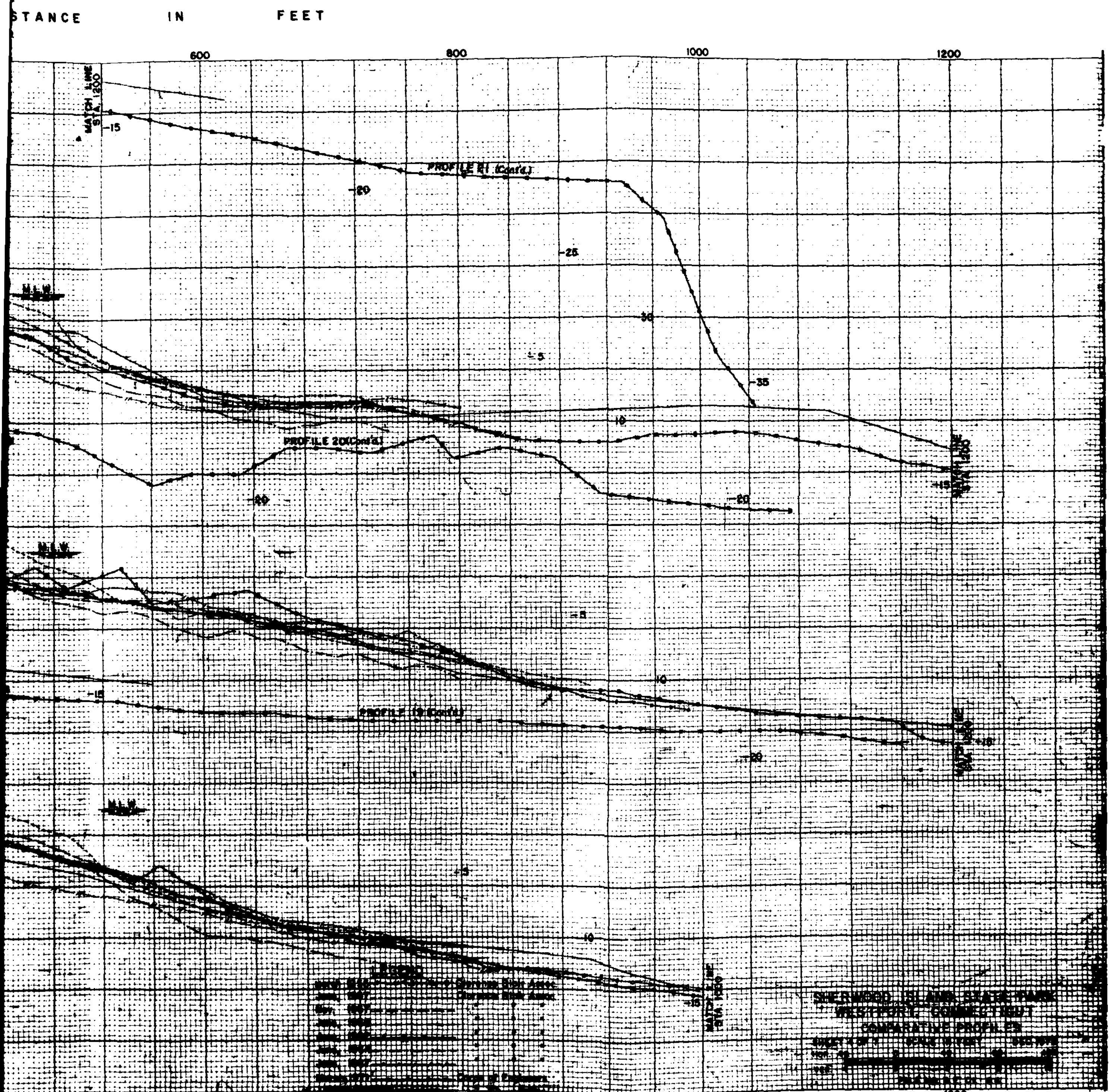
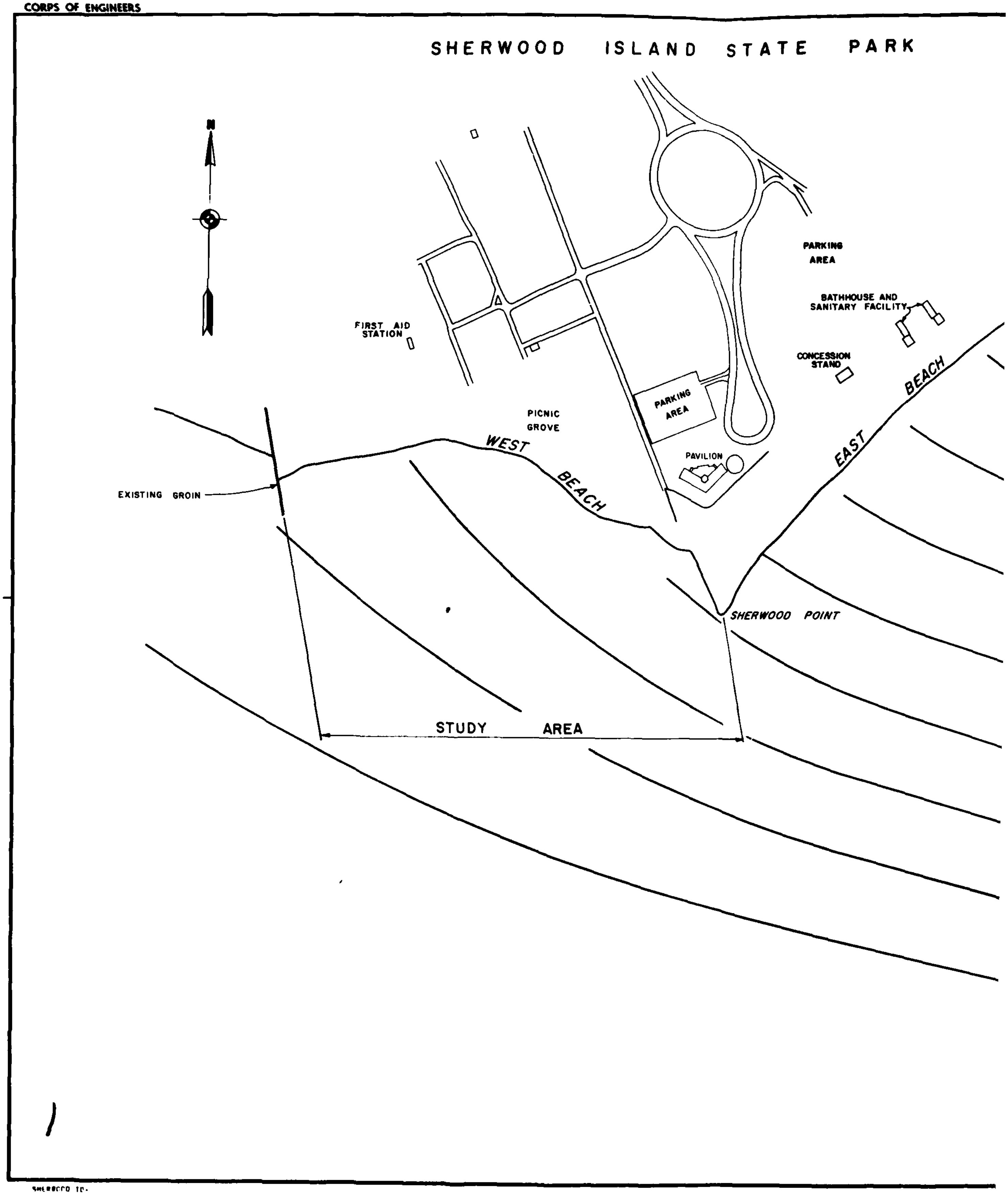

STANCE IN FEET
600
800
1000
1200
MATCH LINE STA. 1200
PROFILE 21 (Cont'd.)
PROFILE 20 (Cont'd.)
PROFILE 19 (Cont'd.)
M.L.W.
LEGEND
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
COMPARATIVE PROFILES

PLATE 1 - 5

2

CORPS OF ENGINEERS



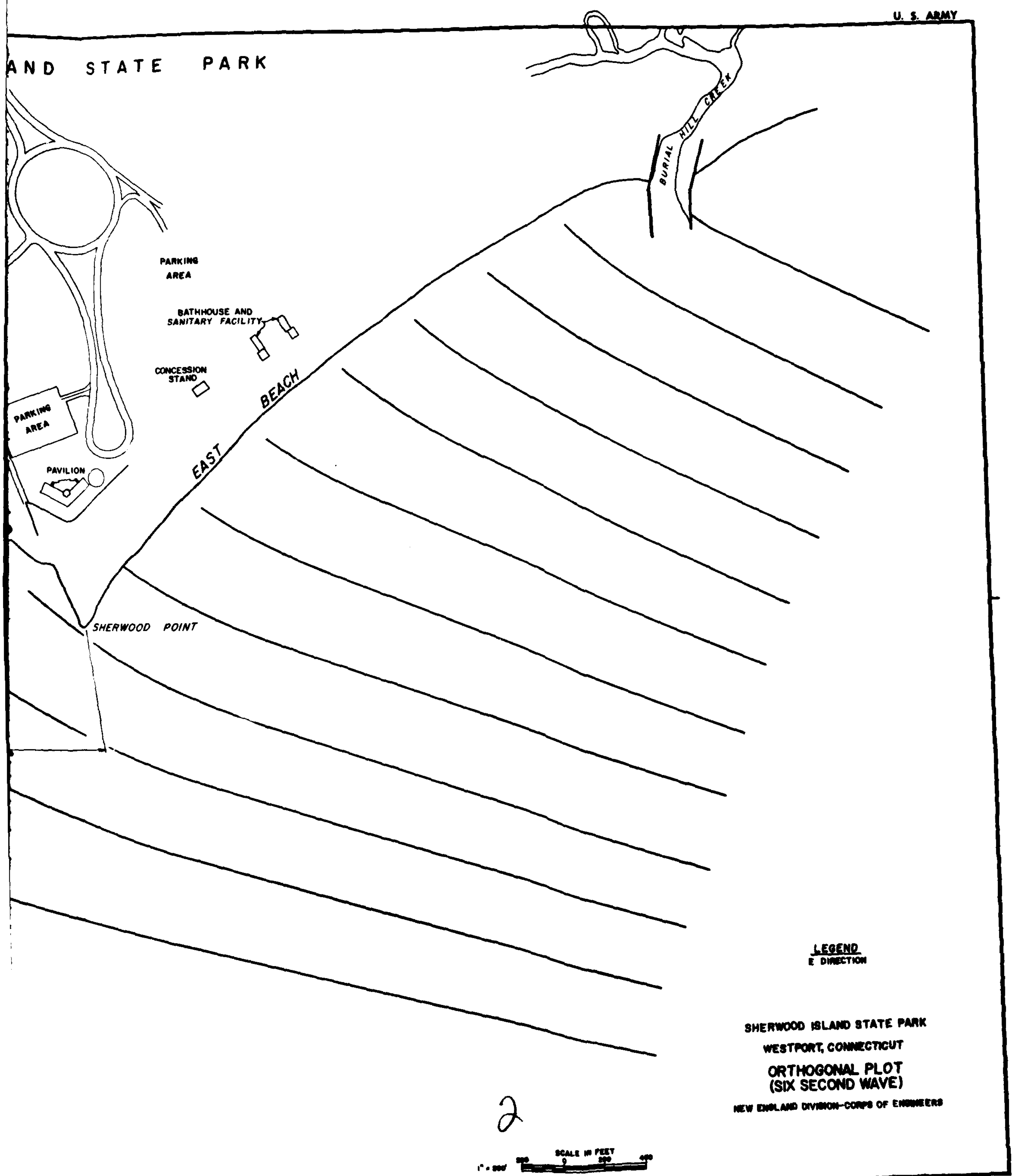
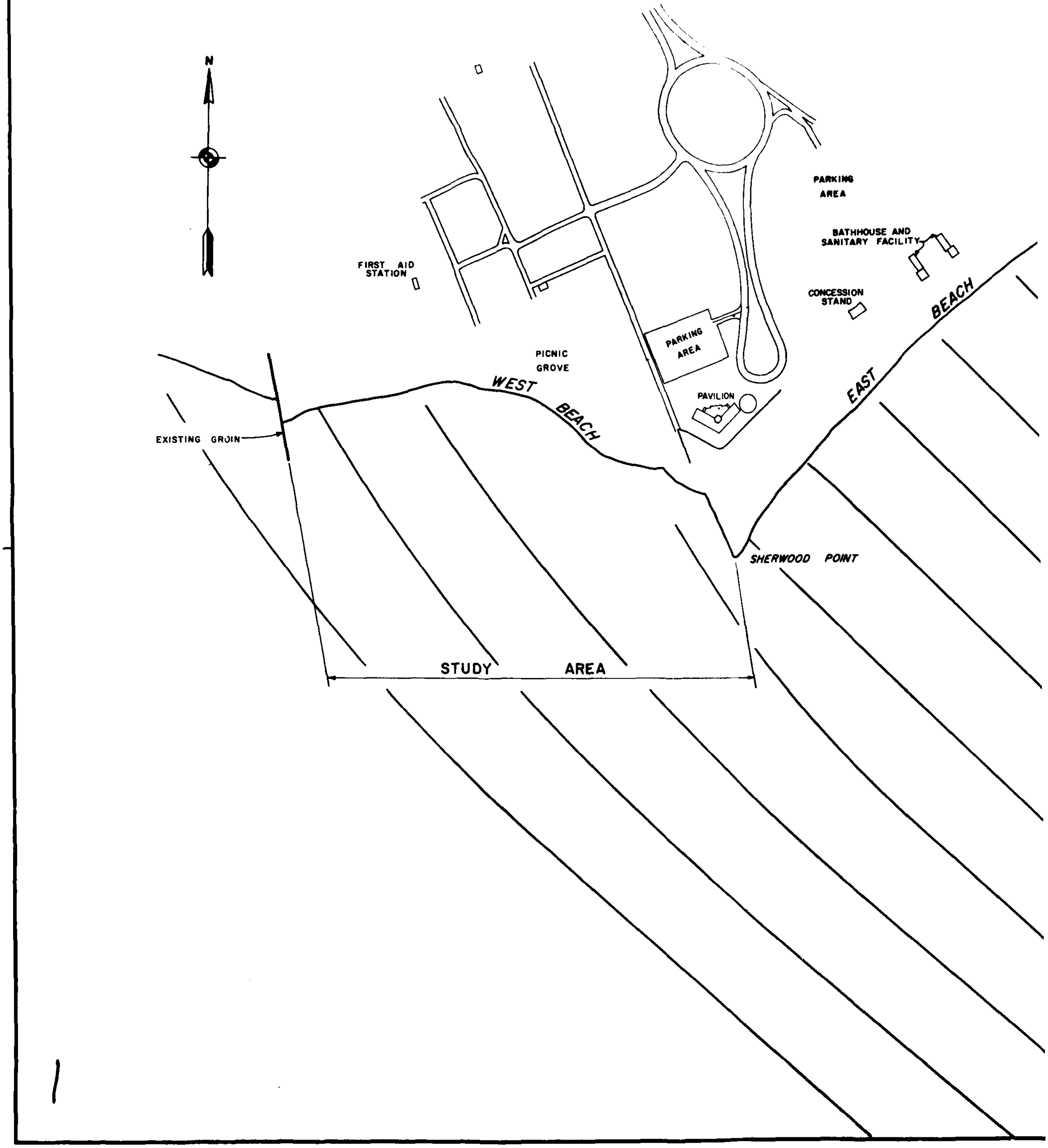

U. S. ARMY
AND STATE PARK
BURIAL HILL CREEK
PARKING AREA
BATHHOUSE AND SANITARY FACILITY
CONCESSION STAND
EAST BEACH
PARKING AREA
PAVILION
SHERWOOD POINT
LEGEND
E DIRECTION
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
ORTHOGONAL PLOT
(SIX SECOND WAVE)
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
SCALE IN FEET
2

PLATE I-6

CORPS OF ENGINEERS

SHERWOOD ISLAND STATE PARK



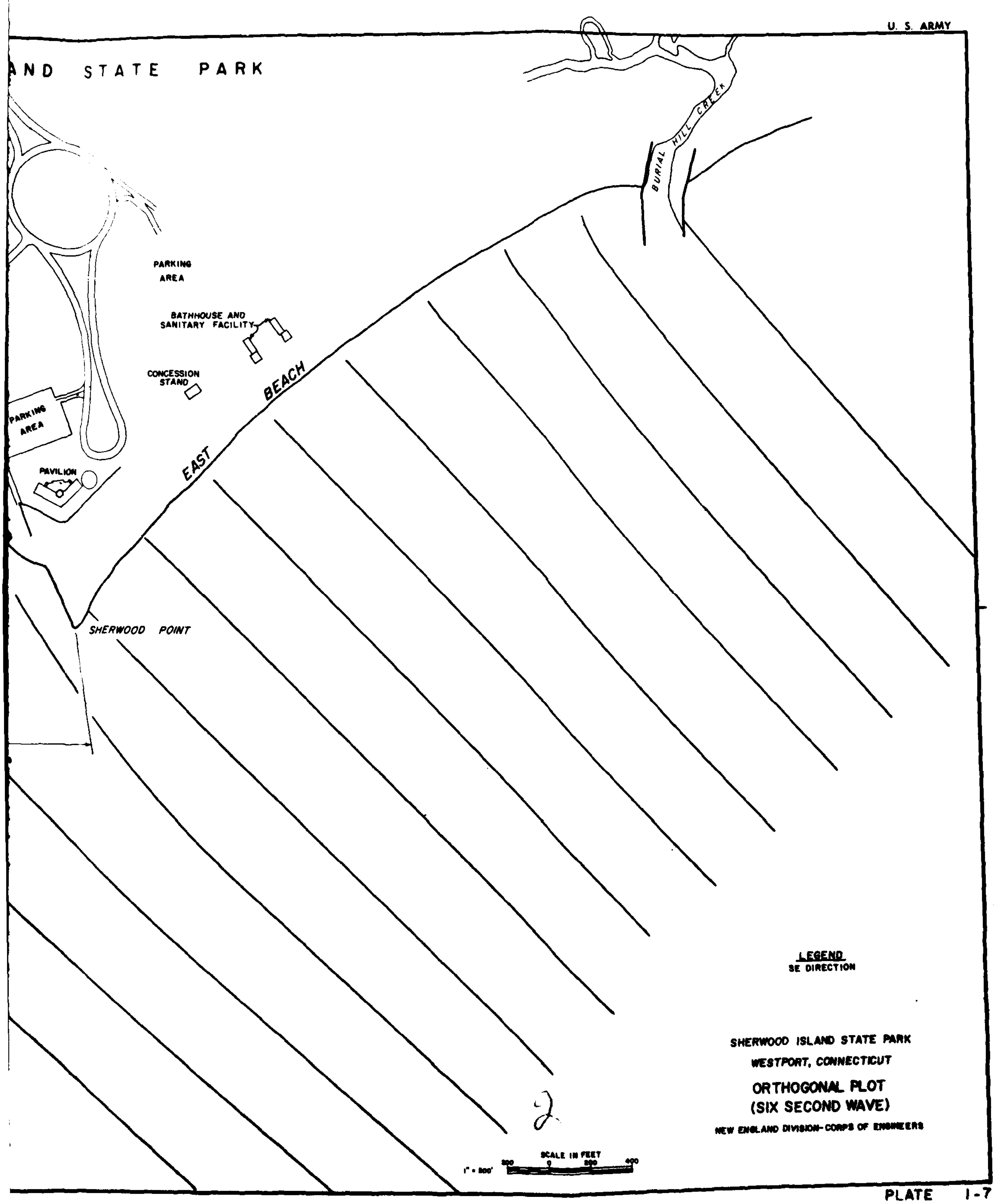
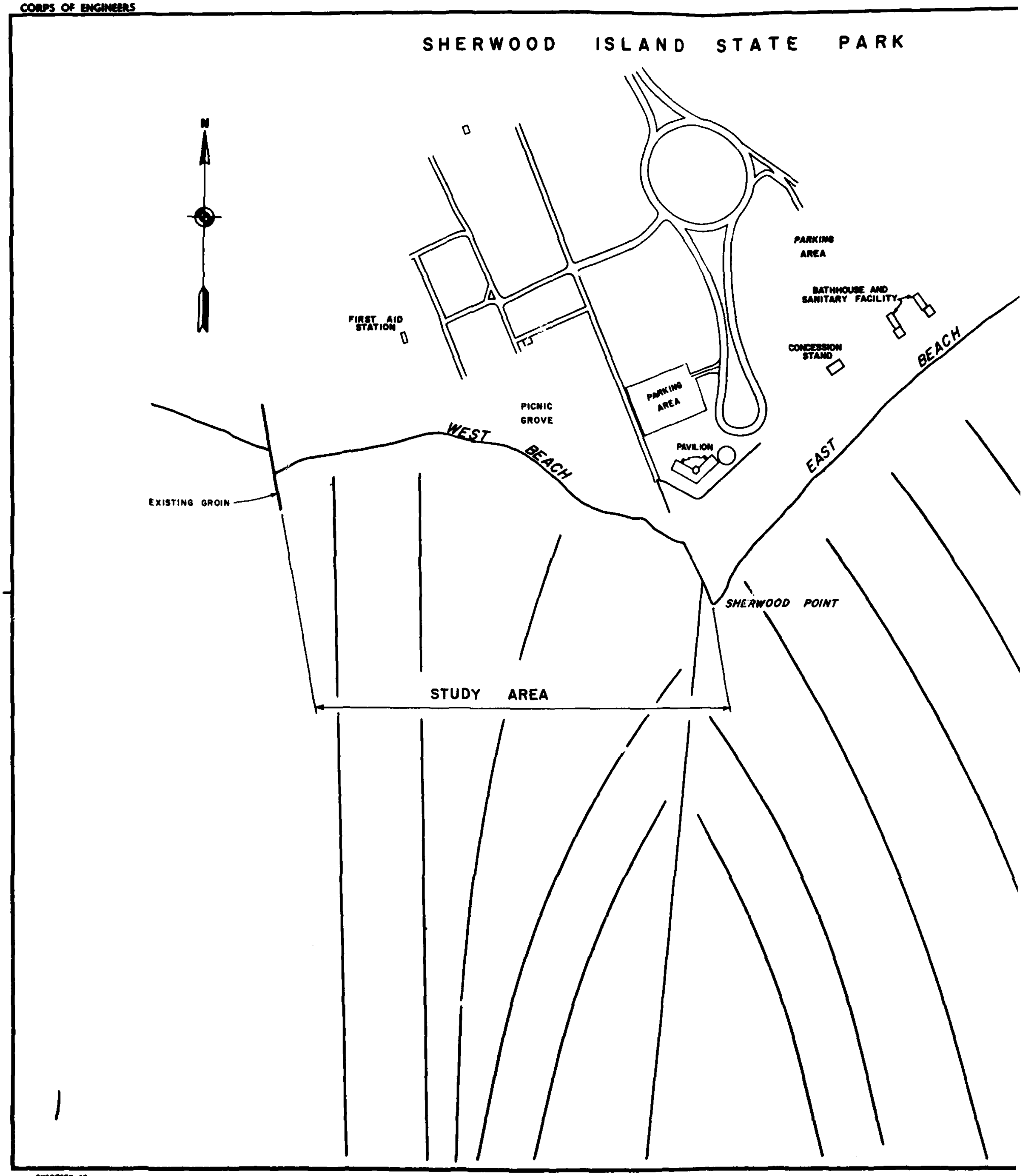

U. S. ARMY
AND STATE PARK
BURIAL HILL CREEK
PARKING AREA
BATHHOUSE AND SANITARY FACILITY
CONCESSION STAND
PARKING AREA
PAVILION
EAST BEACH
SHERWOOD POINT
LEGEND
SE DIRECTION
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
ORTHOGONAL PLOT
(SIX SECOND WAVE)
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
SCALE IN FEET

PLATE 1-7

CORPS OF ENGINEERS



SHERWOOD ID.

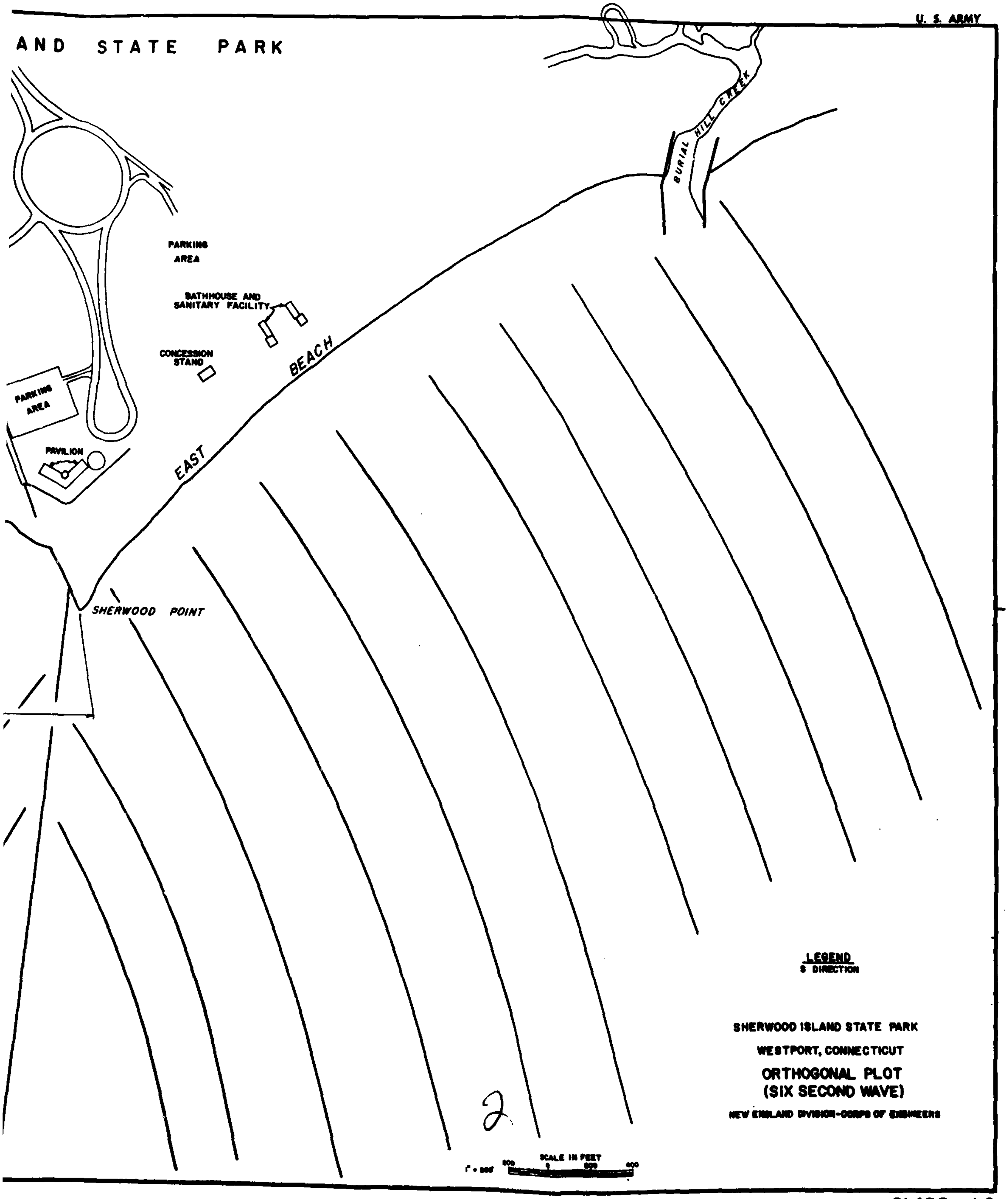
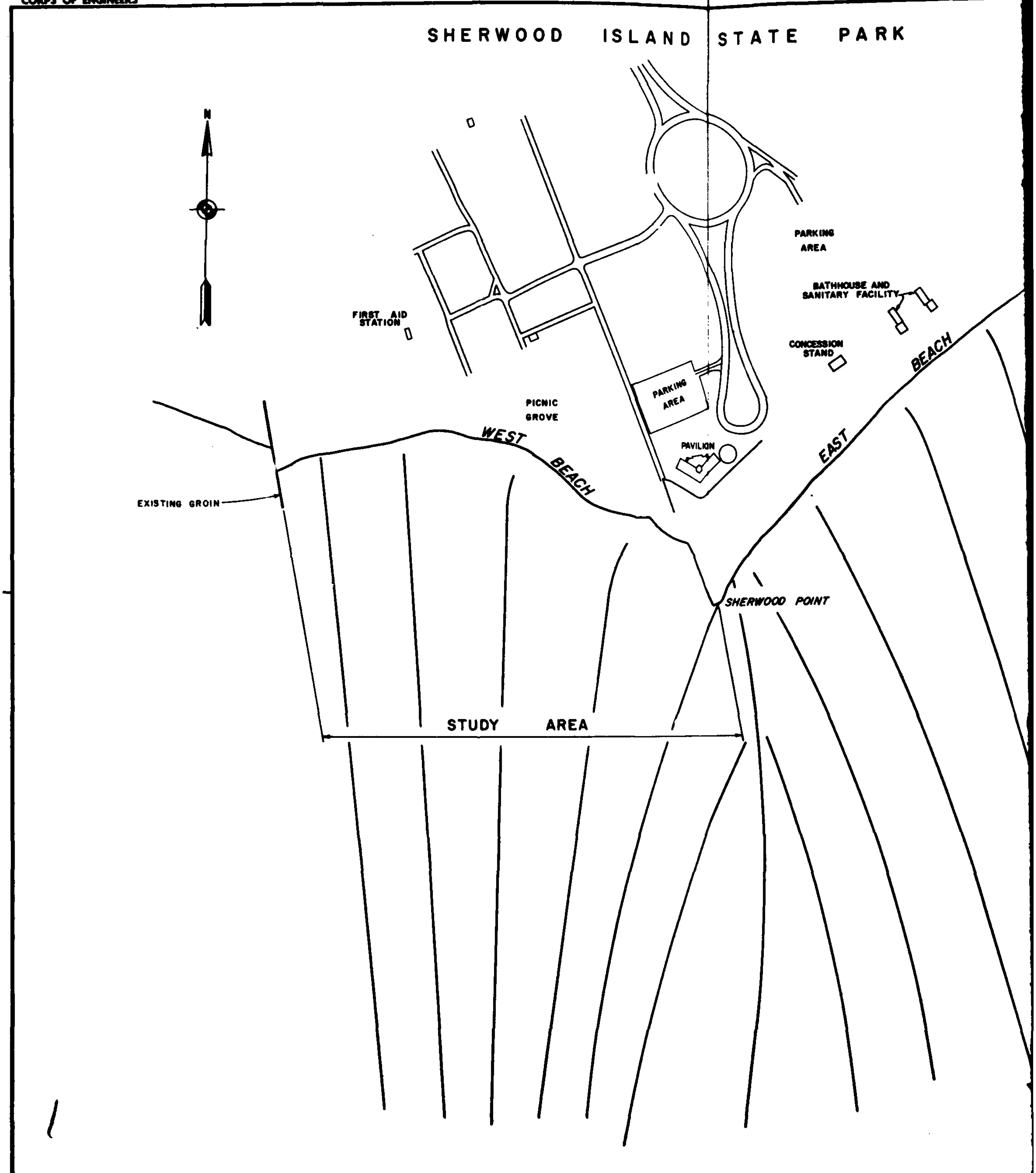

U. S. ARMY
AND STATE PARK
PARKING AREA
BATHHOUSE AND SANITARY FACILITY
CONCESSION STAND
PARKING AREA
PAVILION
EAST BEACH
BURIAL HILL CREEK
SHERWOOD POINT
LEGEND
S DIRECTION
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
ORTHOGONAL PLOT
(SIX SECOND WAVE)
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
2
SCALE IN FEET
200 0 200 400

PLATE I-8

CORPS OF ENGINEERS



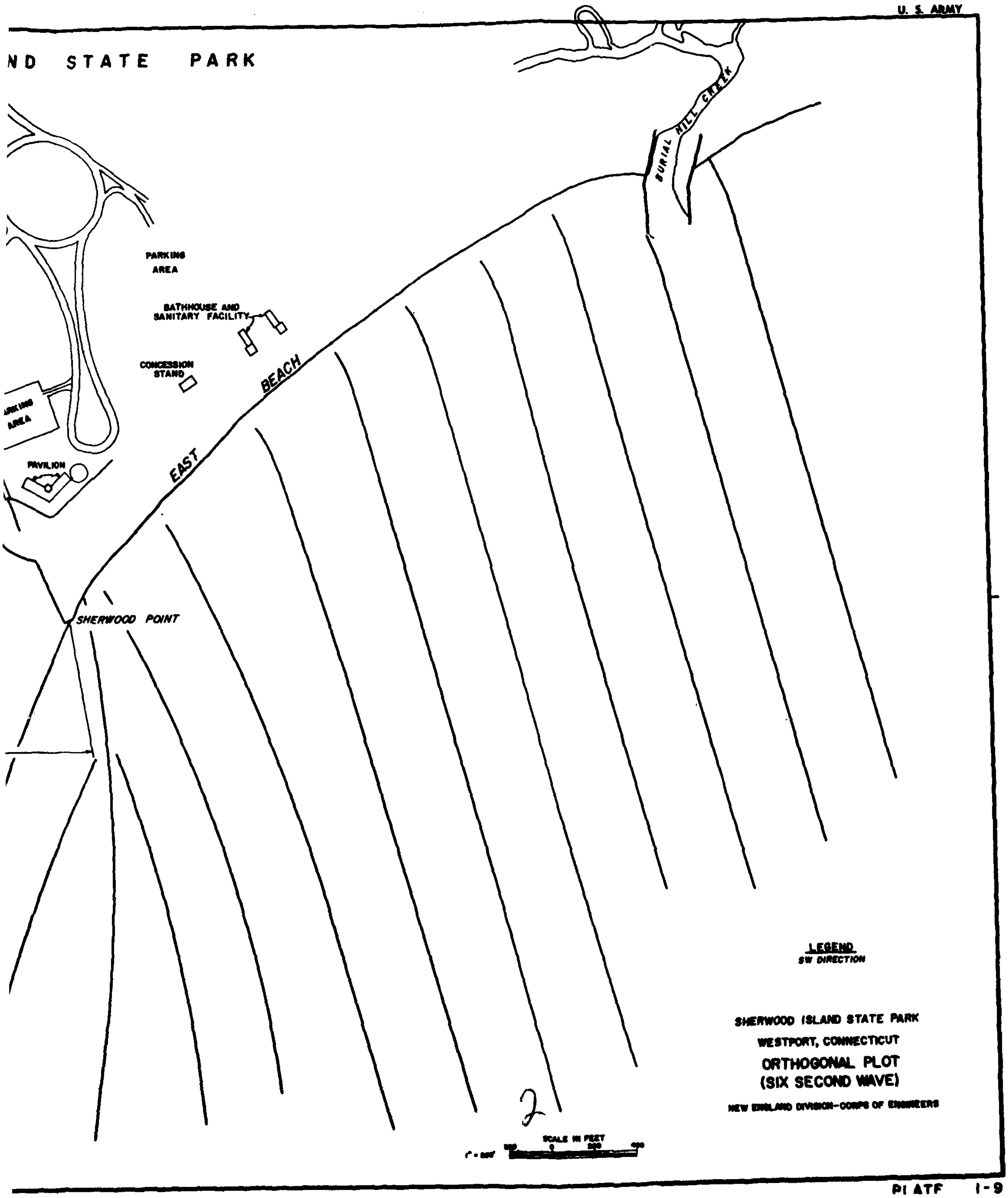
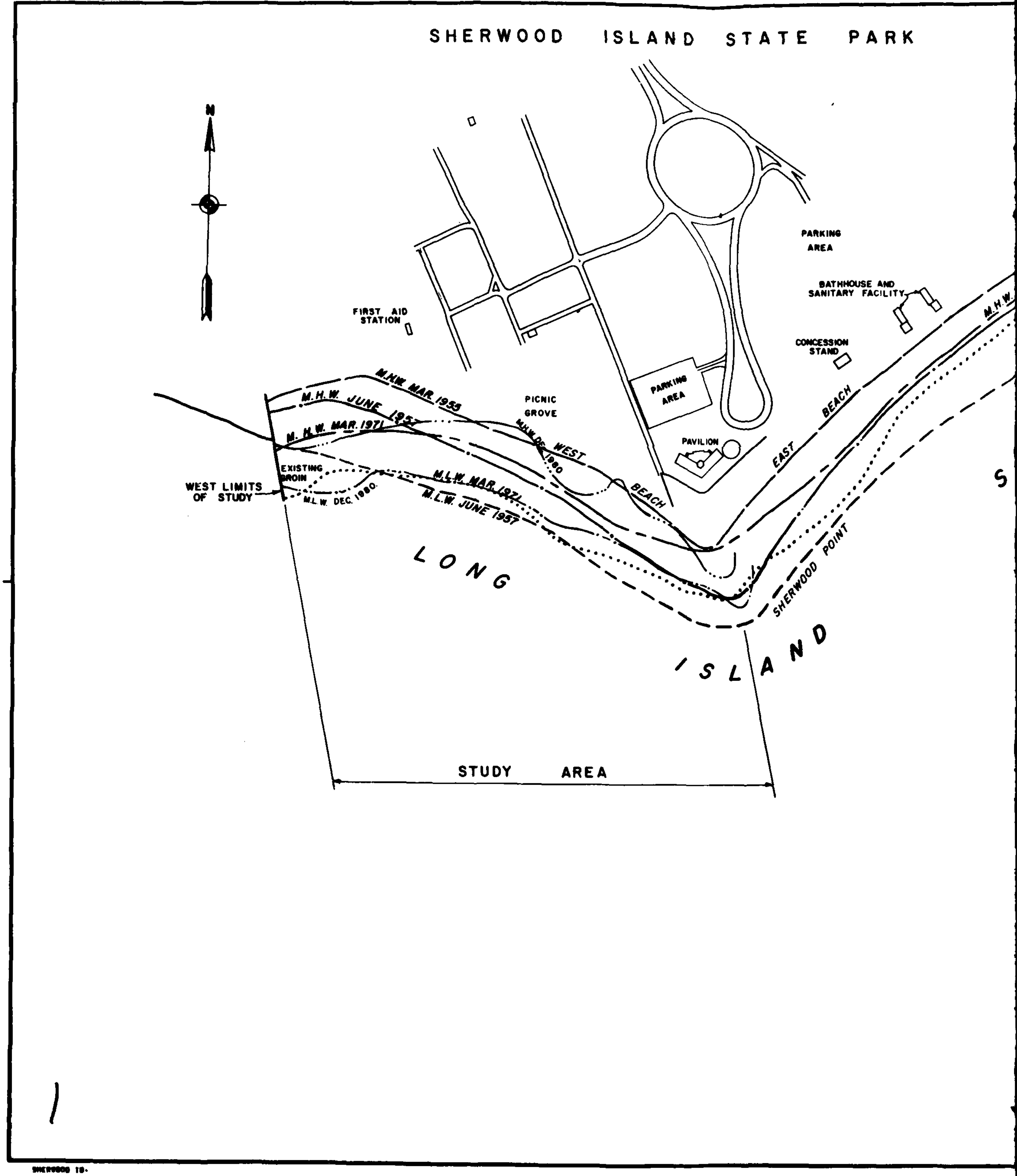

U. S. ARMY
ND STATE PARK
BURIAL HILL CREEK
PARKING AREA
BATHHOUSE AND SANITARY FACILITY
CONCESSION STAND
EAST BEACH
PARKING AREA
PAVILION
SHERWOOD POINT
LEGEND
SW DIRECTION
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
ORTHOGONAL PLOT
(SIX SECOND WAVE)
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
2
SCALE IN FEET

PLATE I-9

CORPS OF ENGINEERS



SHERWOOD 19-

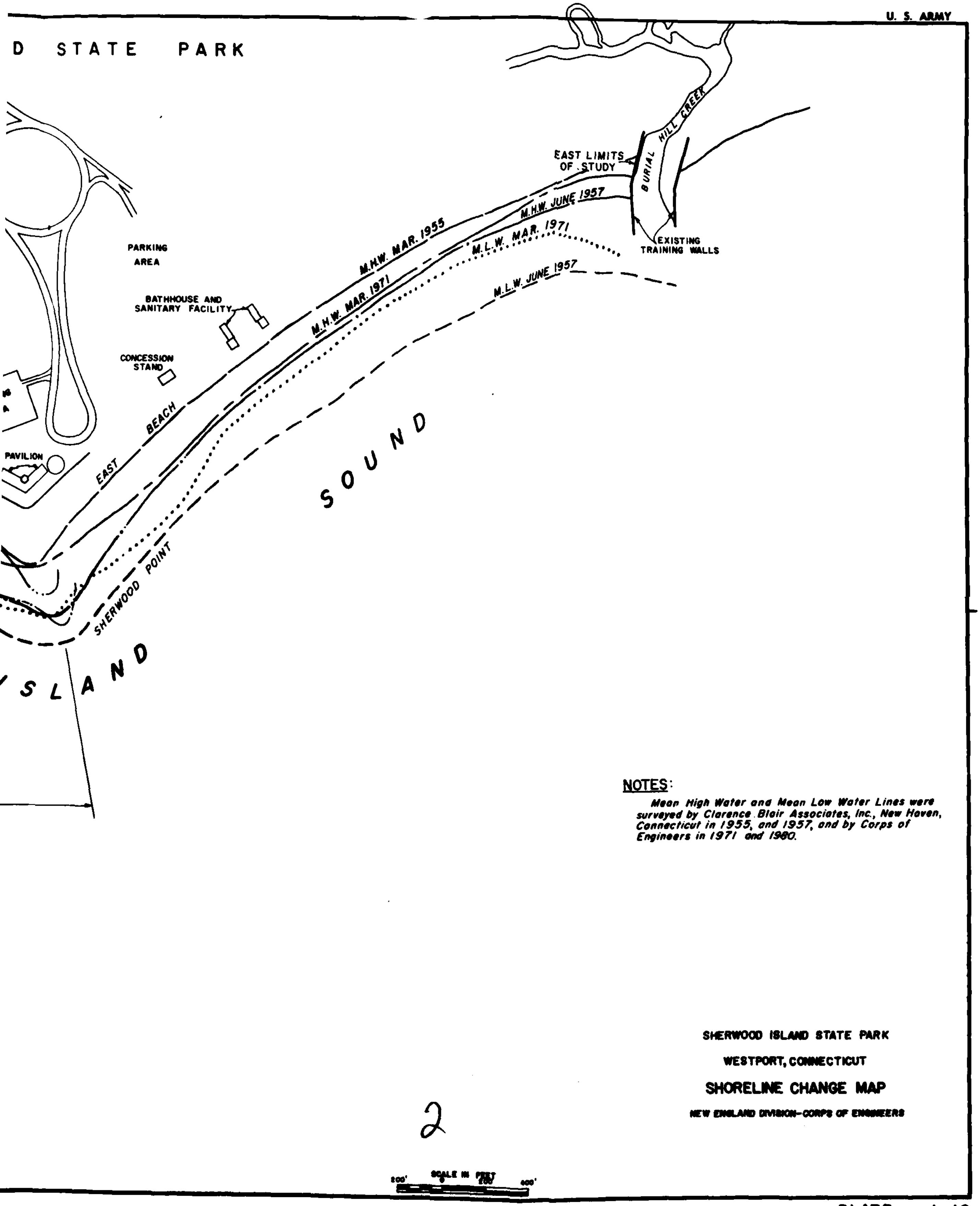
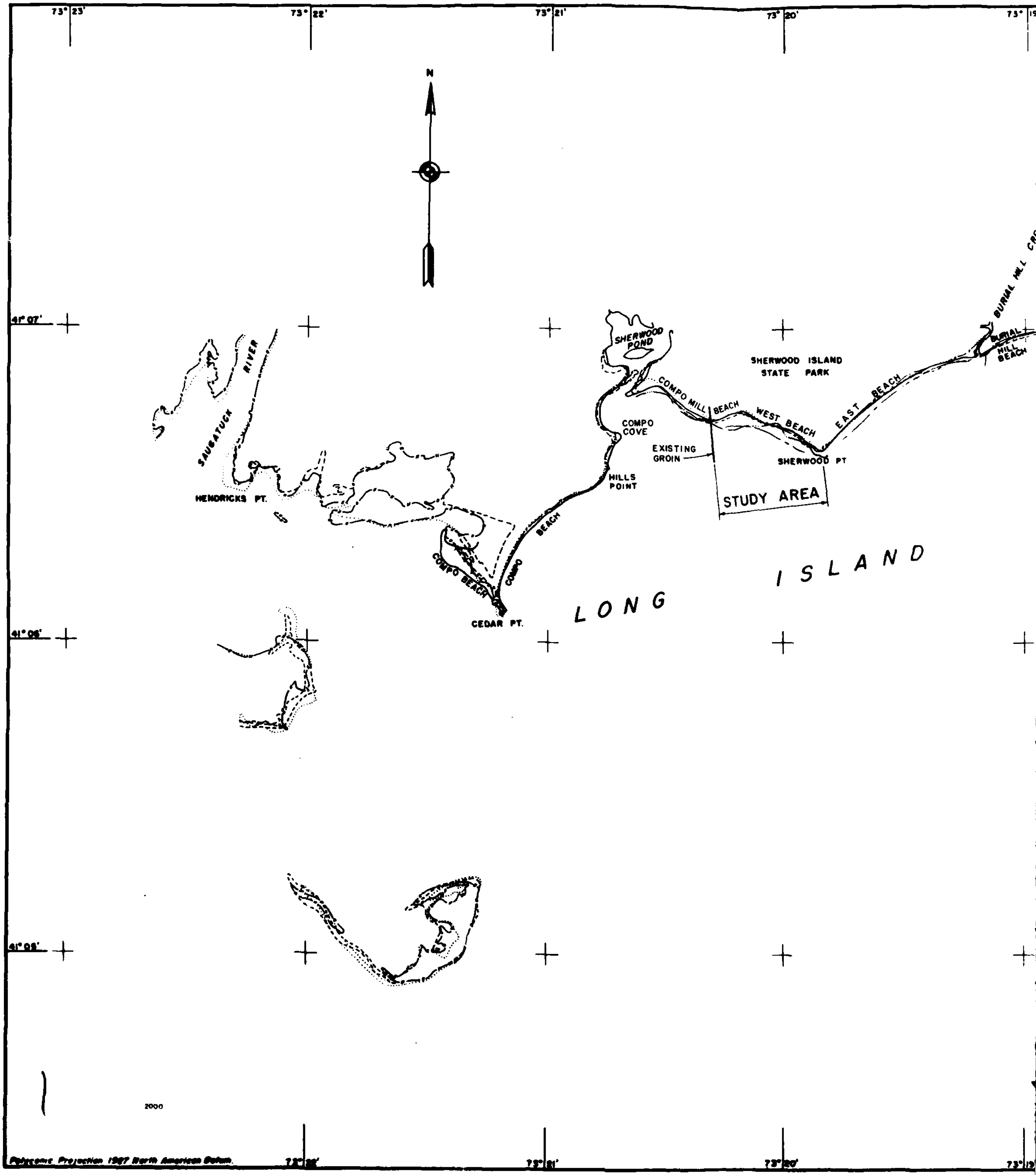

U. S. ARMY
D STATE PARK
PARKING AREA
BATHHOUSE AND SANITARY FACILITY
CONCESSION STAND
PAVILION
EAST BEACH
SHERWOOD POINT
SOUND
SLAND
M.H.W. MAR. 1955
M.H.W. JUNE 1957
M.H.W. MAR. 1971
M.L.W. MAR. 1971
M.L.W. JUNE 1957
EAST LIMITS OF STUDY
BURIAL HILL CREEK
EXISTING TRAINING WALLS
NOTES:
Mean High Water and Mean Low Water Lines were surveyed by Clarence Blair Associates, Inc., New Haven, Connecticut in 1955, and 1957, and by Corps of Engineers in 1971 and 1980.
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
SHORELINE CHANGE MAP
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
2
SCALE IN FEET

PLATE I-10

CORPS OF ENGINEERS



U.S. ARMY

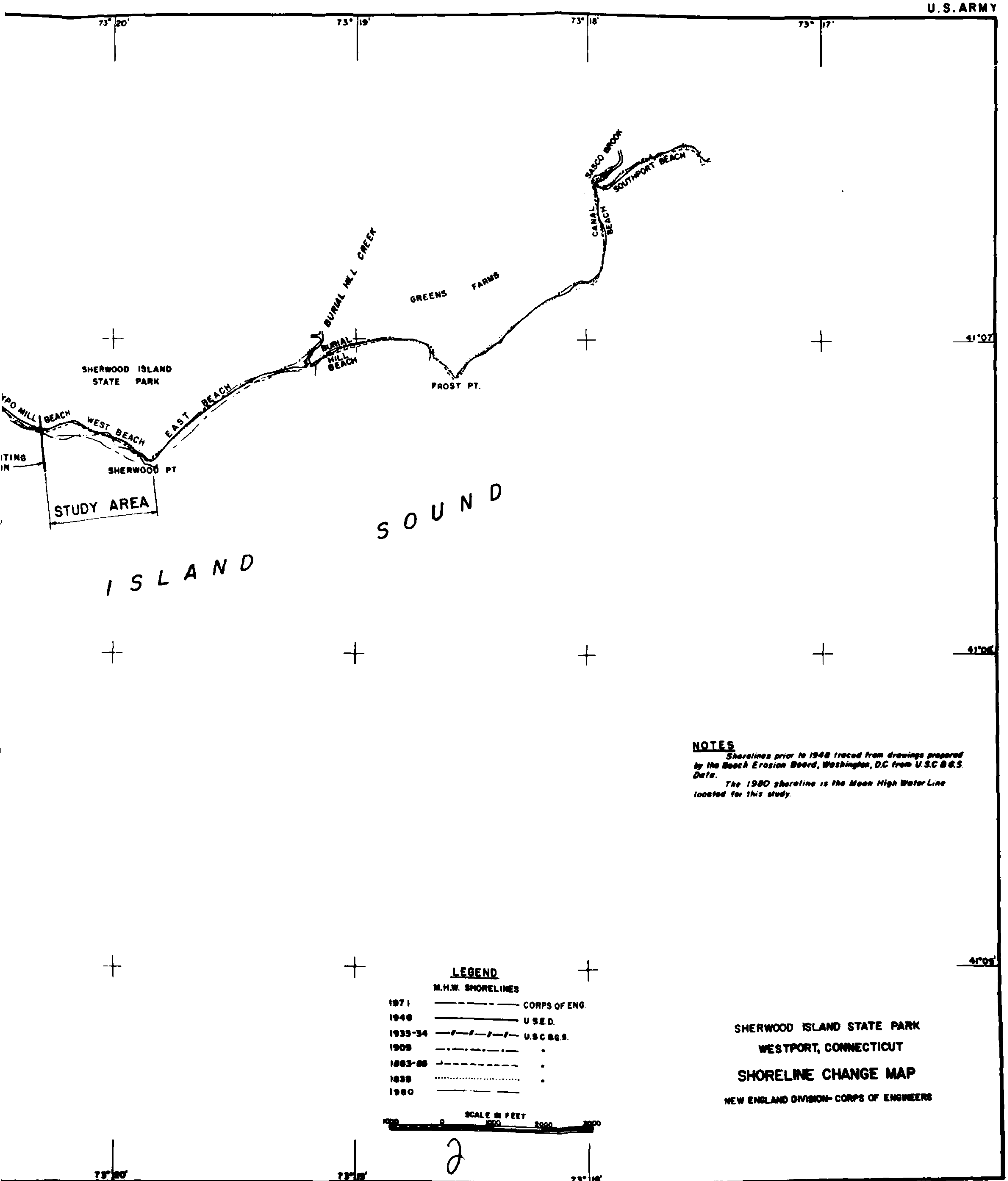
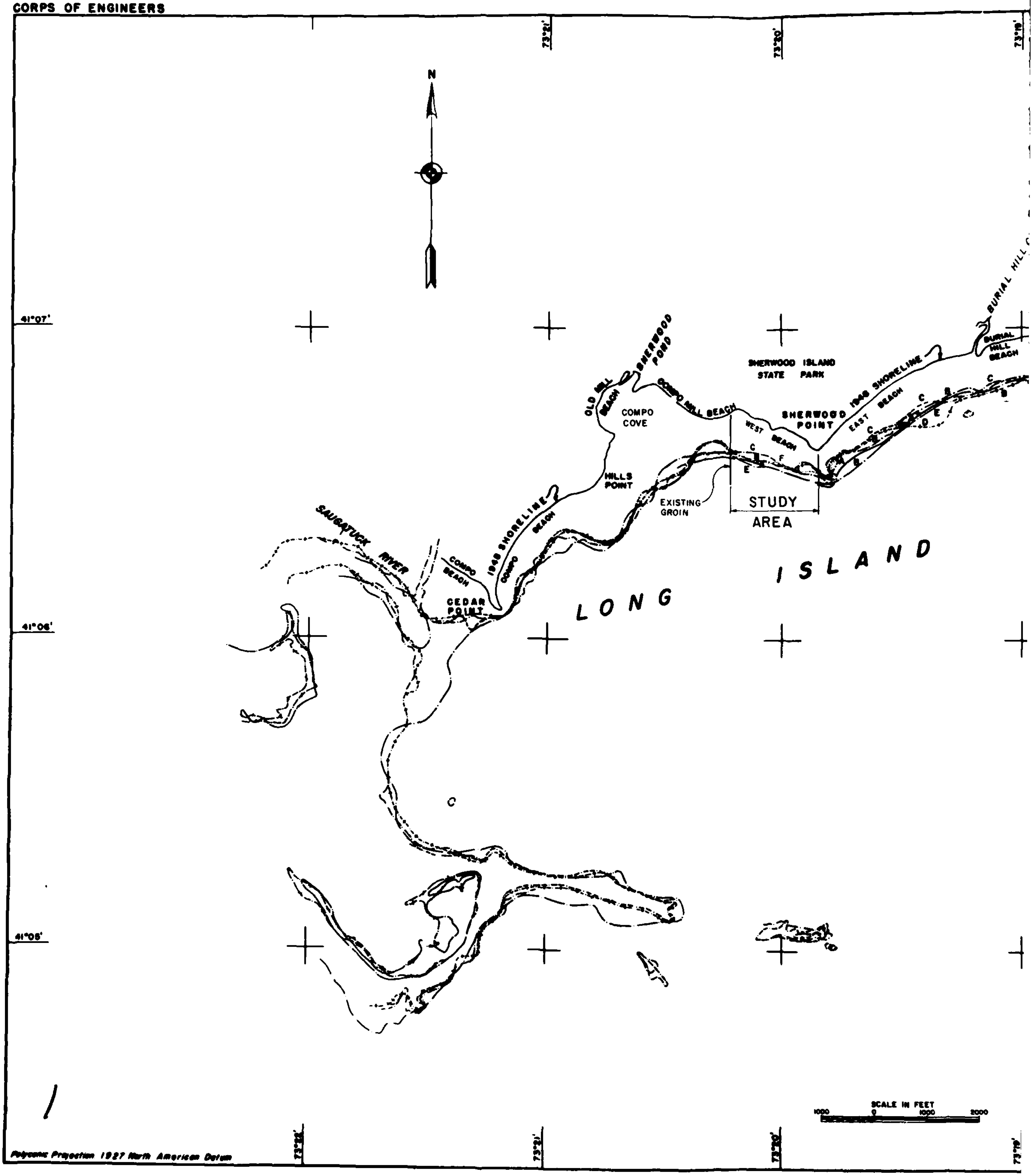


PLATE I-11

CORPS OF ENGINEERS



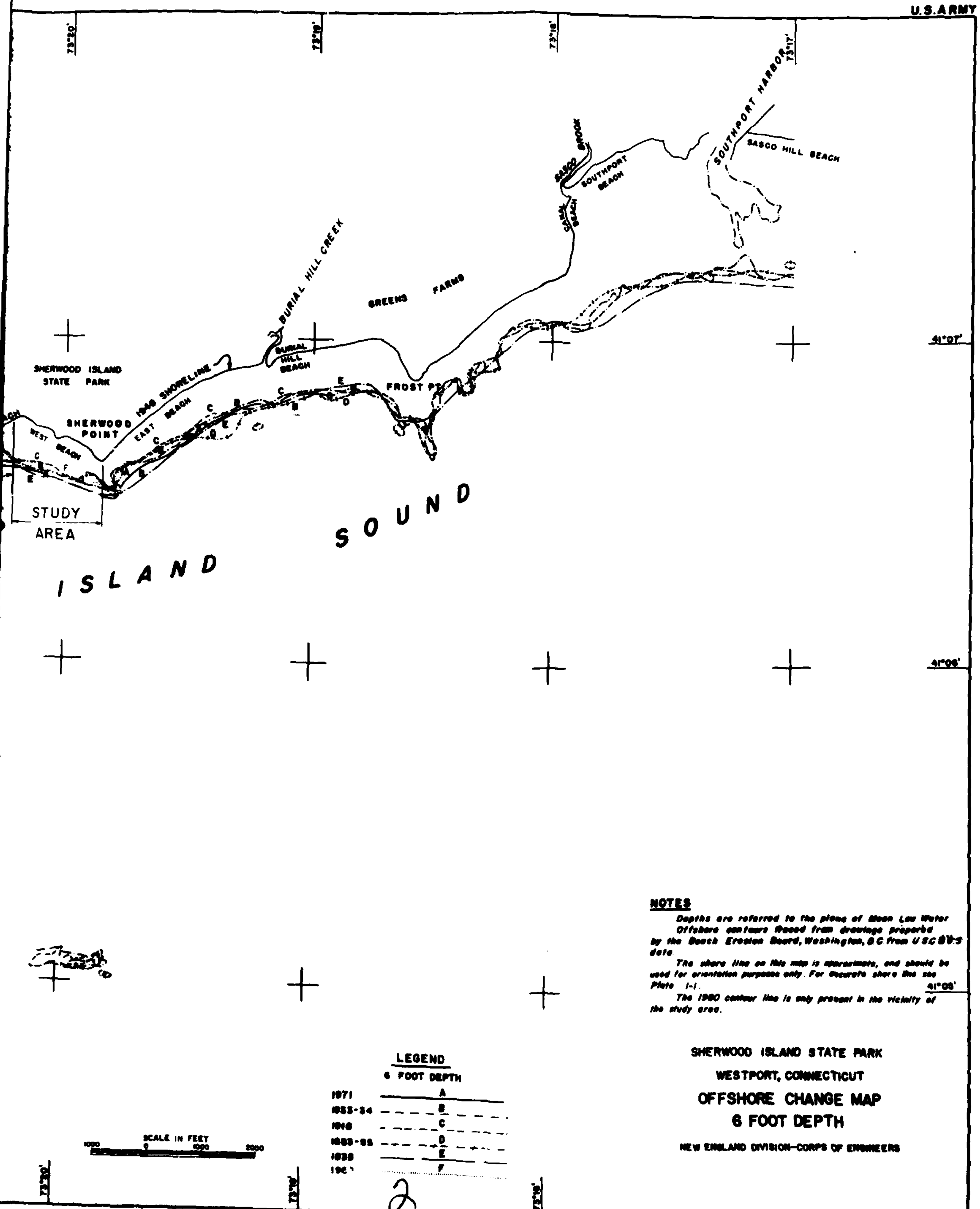
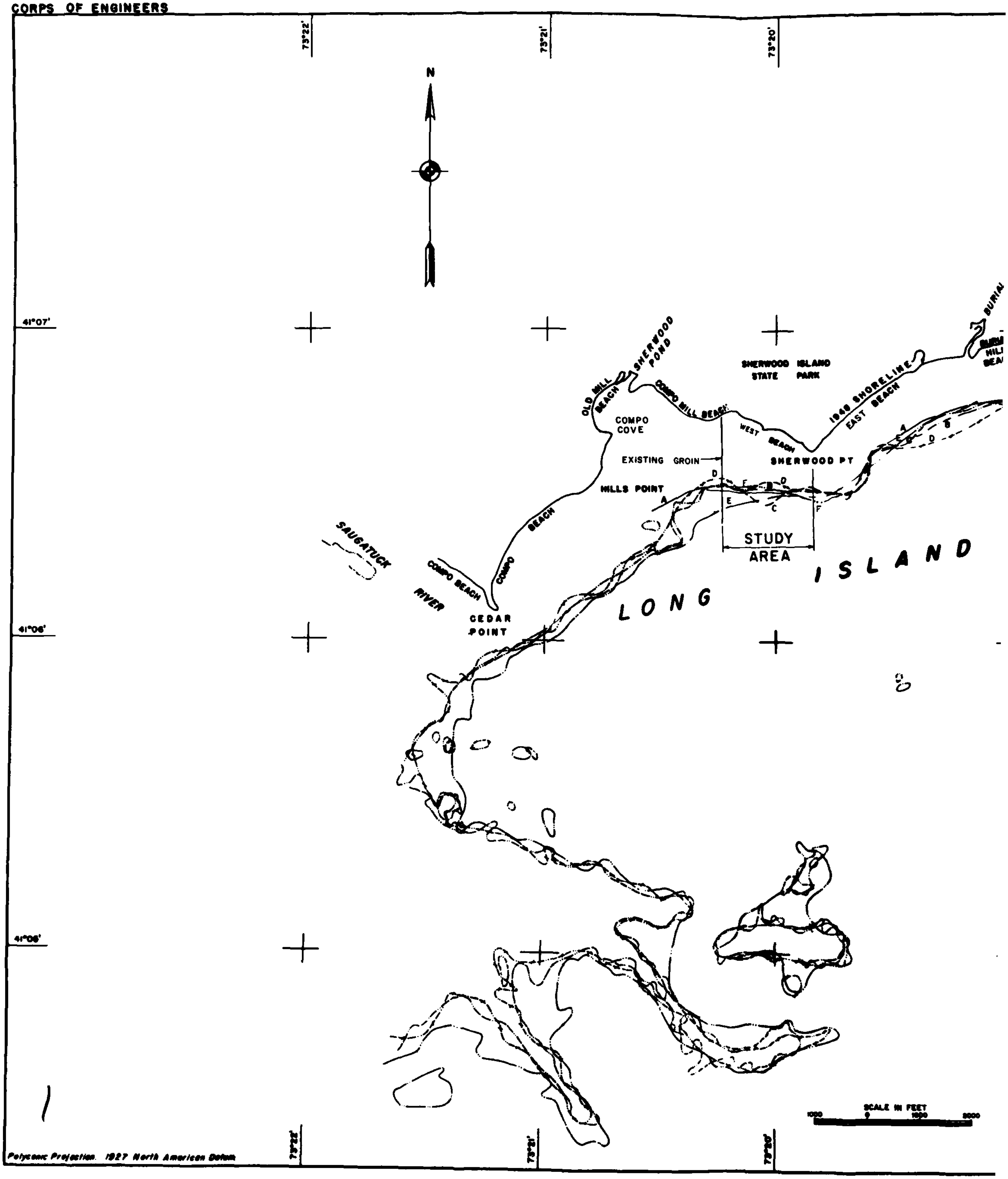

U.S.ARMY
73°20'
73°19'
73°18'
73°17'
SOUTHPORT HARBOR
SASCO HILL BEACH
SASCO BROOK
SOUTHPORT BEACH
CANAL BEACH
BURIAL HILL CREEK
GREENS FARMS
BURIAL HILL BEACH
SHERWOOD ISLAND STATE PARK
1948 SHORELINE
EAST BEACH
SHERWOOD POINT
WEST BEACH
FROST PT
41°07'
STUDY AREA
ISLAND SOUND
41°06'
41°05'
NOTES
Depths are referred to the plane of Mean Low Water
Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.
The shore line on this map is approximate, and should be used for orientation purposes only. For accurate shore line see Plate 1-1.
The 1980 contour line is only present in the vicinity of the study area.
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
OFFSHORE CHANGE MAP
6 FOOT DEPTH
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
LEGEND
6 FOOT DEPTH
1971 A
B
C
D
1938 E
F
SCALE IN FEET
1000 0 1000 2000
2

PLATE 1-12

CORPS OF ENGINEERS



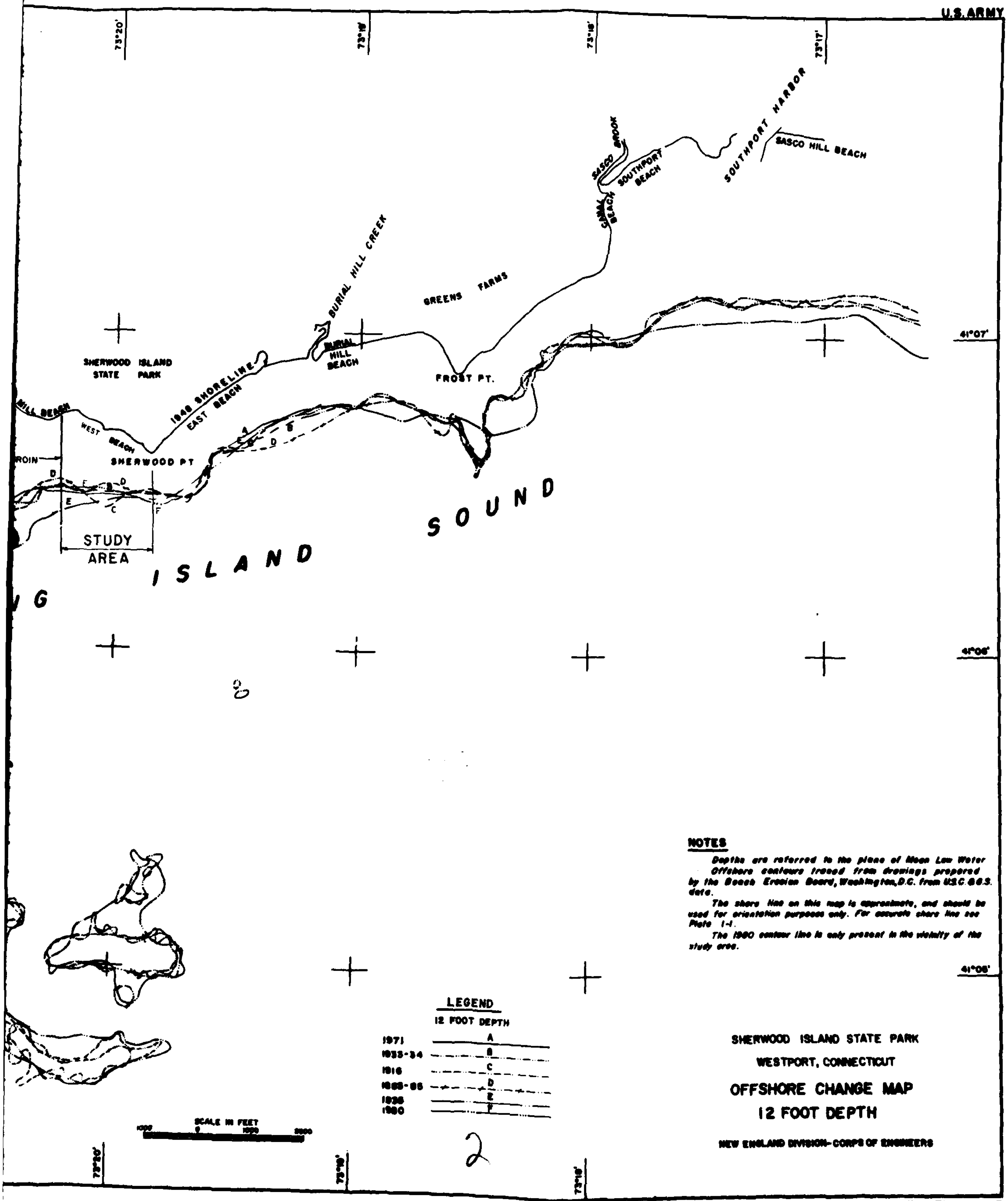
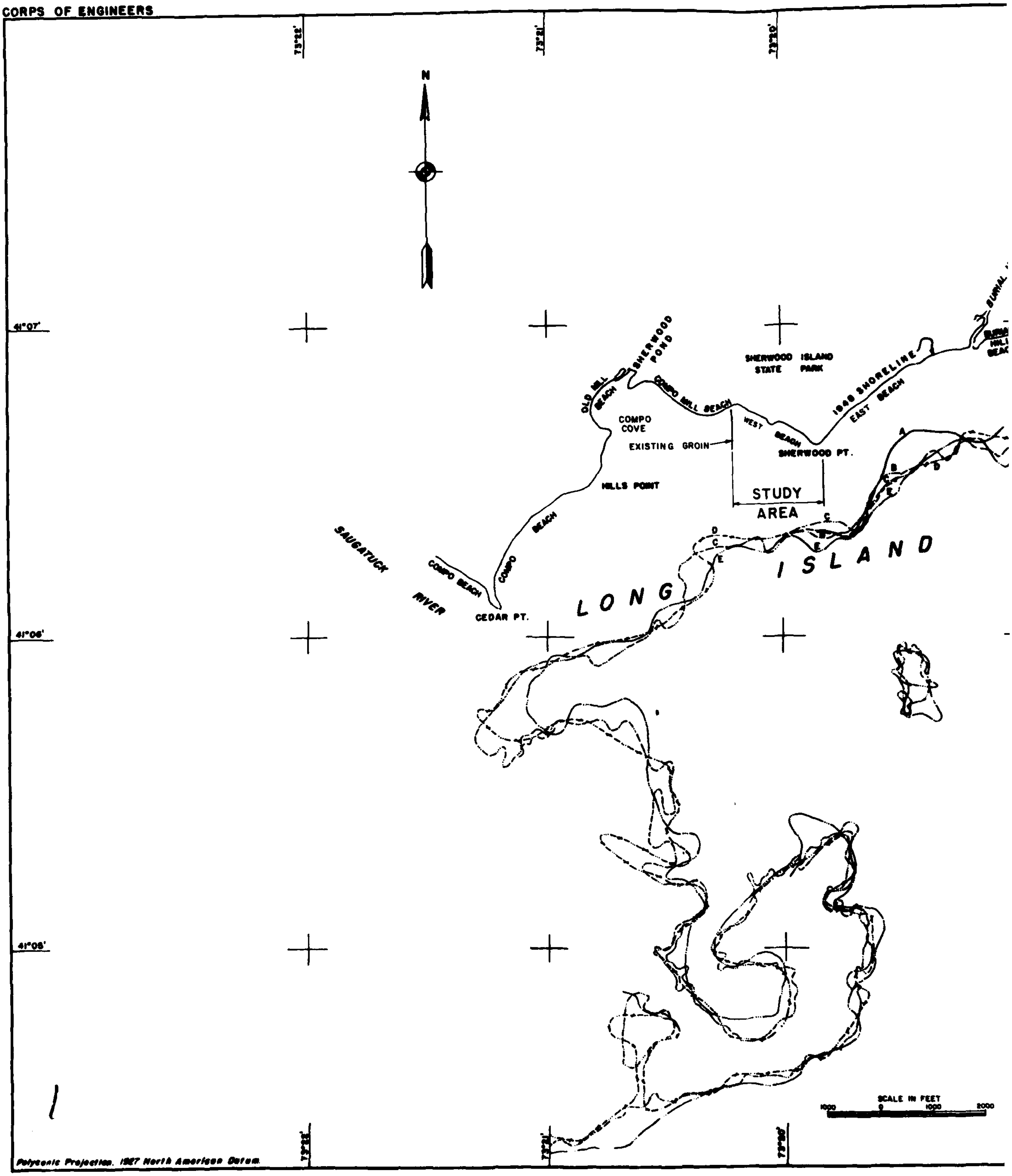
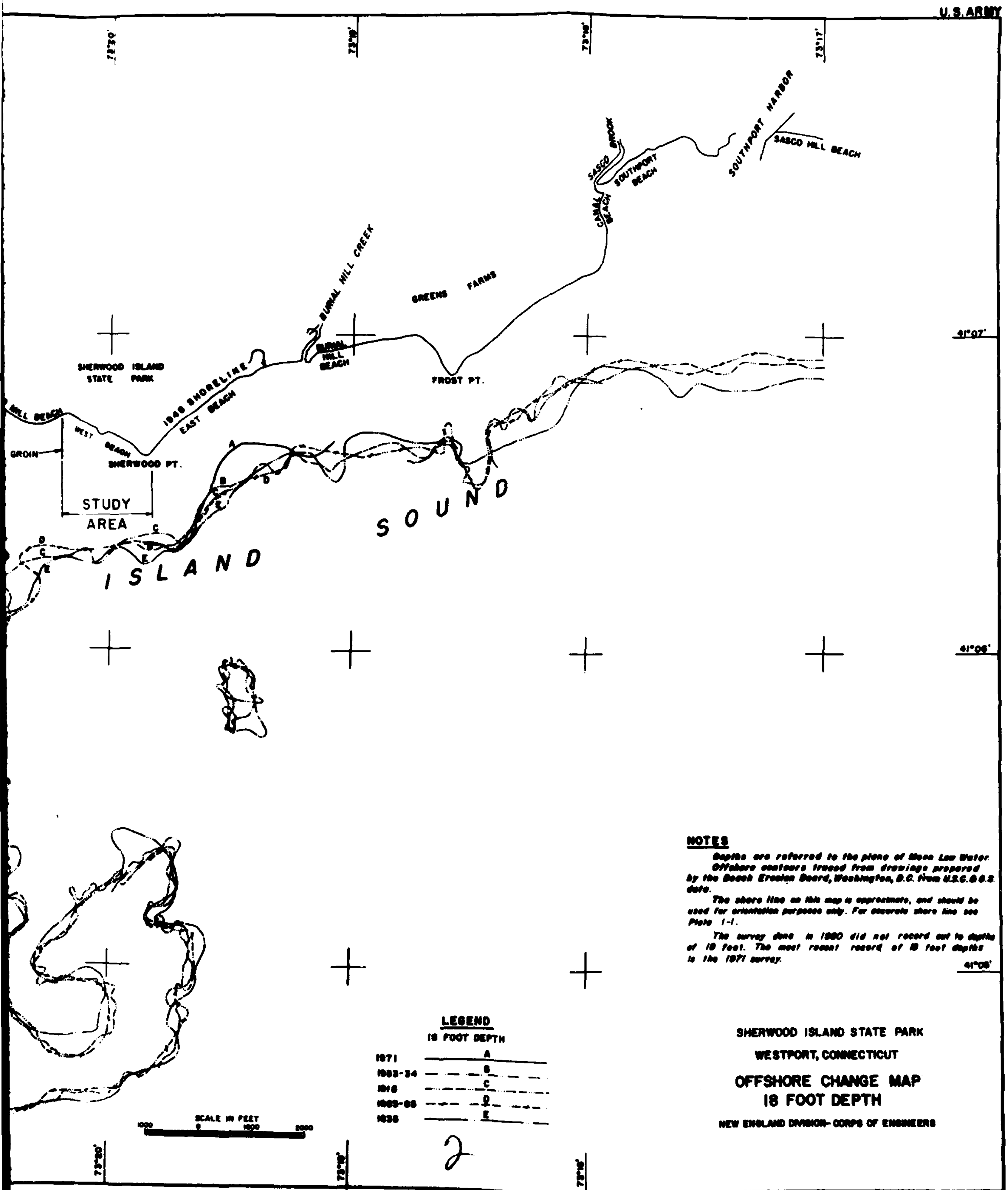

U.S. ARMY
73°20'
73°19'
73°18'
73°17'
41°07'
41°06'
41°05'
SOUTHPORT HARBOR
SASCO HILL BEACH
SASCO BROOK
SOUTHPORT BEACH
CANAL BEACH
BURIAL HILL CREEK
GREENS FARMS
BURIAL HILL BEACH
FROST PT.
SHERWOOD ISLAND STATE PARK
1948 SHORELINE
EAST BEACH
WEST BEACH
SHERWOOD PT
STUDY AREA
LONG ISLAND SOUND
NOTES
Depths are referred to the plane of Mean Low Water
Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.
The shore line on this map is approximate, and should be used for orientation purposes only. For accurate shore line see Plate 1-1.
The 1980 contour line is only present in the vicinity of the study area.
LEGEND
12 FOOT DEPTH
1971 A
1933-34 B
1916 C
1885-86 D
1936 E
1980 F
SCALE IN FEET
1000 0 1000 2000
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT
OFFSHORE CHANGE MAP
12 FOOT DEPTH
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
2

PLATE 1-13

CORPS OF ENGINEERS





NOTES

Depths are referred to the plane of Mean Low Water.

Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

The shore line on this map is approximate, and should be used for orientation purposes only. For accurate shore line see Plate 1-1.

The survey done in 1960 did not record out to depths of 18 feet. The most recent record of 18 foot depths is the 1971 survey.

LEGEND

18 FOOT DEPTH

1971 A
1933-34 B
1916 C
1885-86 D
1836 E

SHERWOOD ISLAND STATE PARK

WESTPORT, CONNECTICUT

OFFSHORE CHANGE MAP
18 FOOT DEPTH

NEW ENGLAND DIVISION- CORPS OF ENGINEERS

2

PLATE 1-14

C

APPENDIX 2

FORMULATION, ASSESSMENT AND EVALUATION OF DETAILED PLANS

FORMULATION, ASSESSMENT, AND EVALUATION OF DETAILED PLANS

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FORMULATION, ASSESSMENT, AND

EVALUATION OF DETAILED PLANS

This appendix will focus on further development of detailed plans to satisfy the planning and national objectives as well as the needs of Sherwood Island State Park, Westport, Connecticut.

FORMULATION AND EVALUATION CRITERIA

The process of evaluating plans was carried out by establishing the contributions of each alternative in relation to the planning objectives for planning beach erosion control projects. The alternative plans must meet the criteria specified in the National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE) accounts set forth in the Water Resource Council's "Principles and Standards for Water and Related Land Resources Planning." Desirability of these plans will depend upon the beneficial and adverse impacts to the planning objectives in the area and are displayed in the System of Accounts, Table 2-1.

Structural and nonstructural plans were formulated and evaluated and were given equal consideration in the planning process. The criteria used in evaluating plans were acceptability, completeness, effectiveness, and efficiency as stated in Principles and Standards; and certainty, geographic scope, NED benefits-cost ratio, reversibility, and stability, which are derived from the first four.

A comparative analysis of the alternative plans was conducted to determine the plan that was the more effective and the least detrimental. Monetary relationships of the plans were taken into effect as well as the social and environmental values. Public preferences were also considered in arriving at the alternative plan which was most acceptable.

The National Objectives for water resource planning requirements were applied in evaluating the plans. The plan that resulted in the maximum net economic return was designated the NED Plan. The plan that resulted in the more positive environmental contributions or was the least environmentally damaging was designated as the EQ Plan.

TECHNICAL CRITERIA

The following technical criteria were adopted in evaluating the study area:

1. Recreational beach improvements should satisfy the projected demands for the 50-year period of analysis.

2. Protection should be designed for winter storms that frequent the area on a basis of once in two years.

3. The extent of the Federal cost of restoring and protecting the beach shall be limited to areas which are landward of the limits of the recorded historic shoreline unless necessary for engineering reasons to provide protection from erosion.

4. Beach berm height should be designed to prevent overtopping by the design tide.

5. Rock revetment and groin structures should be designed with rough or irregular side slopes to break up the waves and reduce scouring.

6. Groins should be designed to compartmentalize the sandfill, not to interrupt or prevent the downdrift shores from being nourished.

ECONOMIC CRITERIA

The economic criteria used in evaluating the considered plans of protection were established as being the most practical methods of meeting the planning criteria and objectives.

1. Each plan must provide benefits at least equal to or greater than its costs in order to be considered as a justified plan.

2. Each plan should provide the maximum net benefits possible within the formulation framework.

3. The cost of the alternative plans is based on preliminary lay-outs, detailed surveys, and estimates of quantities which are based on 1981 unit prices.

4. Annual costs and benefits are based on a 50-year amortization period and an interest rate of 7-3/8 percent.

5. Annual charges include the cost of periodic nourishment.

6. Each plan should provide the minimum cost possible within the formulation framework.

7. The plans include the effects of:

a. Prevention of land loss and other physical damages
b. Reduction in maintenance costs
c. Increased recreational usage
d. Employment benefits

ENVIRONMENTAL CRITERIA AND OTHER SOCIAL EFFECTS

The goals and policies that are set forth in the current National Environmental Policy Act were considered in evaluating the environmental criteria and social effects in the Sherwood Island area. Adverse and beneficial effects were studied from the initiation of project planning through the design with projected effects on construction, and the operation and maintenance stages. Also, there was a continuous interchanging of views with concerned interest groups in analyzing the various alternative plans of improvements for the area.

The considered plans were evaluated to determine their contribution to the Environmental Quality (EQ) account. The enhancement of the environment or the least adverse effect of the proposed plan of improvement was the primary objective in selecting an EQ plan. The following effects were considered:

Fish and Wildlife Habitat
Water Quality
Air Quality
Cultural Resources
Biological Resources
Noise
Aesthetic Values
Natural Resources

Other social effects considers the direct and indirect implications that will rise from the proposed project on the population and their life style. Consideration was given to the following:

Community disruption
Effects on health, safety, and community well-being
Effects on desired community growth
Effects on educational, cultural, and recreational opportunities
Effects on emergency preparedness

Regional Economic Development is concerned with a project's effect on the region. The following criteria were considered:

Effects on regional recreational activities

Effects on employment, income and economic base

Effects on local commercial and industrial activities

Effects on public services and facilities

Effects on noise during construction or other conditions that would tend to raise the overall noise level of the area over the 50-year period of analysis.

FORMULATION METHODOLOGY

The formulation of a plan of improvement for Sherwood Island State Park considered the desires, needs, and preferences of various interests. The formulation methodology began with suggestions from Federal, State, regional, and local interests. The problems and needs were addressed and identified and were limited to water and related resources in the area.

POSSIBLE SOLUTIONS

Each of the possible solutions and various combinations listed below was considered as preliminary alternative improvements for Sherwood Island.

- beach restoration and nourishment
- groin system with sandfill
- groin system without sandfill
- grass planting
- develop artificial dunes
- rock revetment
- offshore breakwater
- do nothing (no action)

These solutions were studied in the planning process which consisted of the following: selection of alternatives, evaluation of impacts, detailed impact assessment, benefit and cost analysis, final evaluation, and selection of the plan. Throughout this process, continued correspondence with State, regional, and concerned local citizens was maintained for their preferences and views on the project.

INITIAL ALTERNATIVES CONSIDERED

The following considered plans of improvement for Sherwood Island were analyzed for economic, environmental, engineering, and public acceptability:

PLAN 1 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline extending from the east limit of study at Sherwood Point to the west limit of study at the existing Federal groin structure.

PLAN 2 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits and lowering the landward end of the existing Federal groin structure.

PLAN 3 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, lowering the landward end of the existing Federal groin structure, and constructing a low-profile groin structure located approximately 900 feet west of Sherwood Point.

PLAN 4 - This plan contains shore management planning guidelines. It involves managing the use of the backshore facilities and provides additional planning guidance for future public participation in water related activities. These activities include restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dune.

PLAN 5 - This plan consists of constructing a breakwater located 600 feet offshore and fronting West Beach.

PLAN 6 - This plan consists of placing rock revetment along the entire length of backshore of West Beach extending between the existing Federal groin structure and Sherwood Point.

Contacts with concerned interests concluded that some means of protection for Sherwood Island was needed. Plans 5 and 6 were studied but eliminated due to their lack of effectiveness in providing a better recreational beach. These plans do protect the backshore from storm driven waves but do not satisfy the criteria for the National Objectives and the problem and opportunity statements. Plans 1, 2, 3 and 4 contribute to the study objectives of the area and will be evaluated and compared to determine which plan is the best for the area.

WITHOUT PROJECT

The without project alternative was discussed and considered, however, it would not provide any solution to the erosion problem that currently exists. Although this alternative avoids the initial monetary investment, as well as the impacts associated with construction, the

current problems will still remain. Such problems are: inadequate dry beach space for recreational bathing, possible deterioration of existing groin structures and backshore embankment with a loss of valuable beach space, continued wave overtopping of the backshore area, and continued hazards to the bathers due to the poor quality of material which makes up the beach. The continued deterioration of the beach which will produce an irregularly-shaped shoreline that will reduce the aesthetic values of the area.

ANALYSIS OF DETAILED PLANS

The six considered plans of improvement were formulated and evaluated according to the water Resources Council's Principles and Standards. The criteria used in evaluating plans were acceptability, completeness, effectiveness, and efficiency.

Structural and nonstructural measures as well as the "without project" or "do nothing" condition were considered in the planning process. However, in contributing to the problem and opportunity statements Plans 1, 2, 3, and 4 were most favorable. These four plans of improvement would contribute some means of protection against erosion and would contribute to continued recreational use. These plans include constructing by the direct placement of suitable sandfill higher and wider beach berm to limit wave overtopping, constructing a groin structure, periodic nourishment, and shore management planning guidelines.

The proposed plans were evaluated for their greatest contributions to the NED and EQ accounts. Contributions to NED included increased recreational values and further beach development. The four plans of improvement have a minimum adverse effect on the environment in the project area.

BEACH DEVELOPMENT

Throughout the study, which began in the reconnaissance report stage and continued into the Detailed Project Report stage, consideration was given to correcting the erosion problem that currently exists and to contributing to increased recreational use. The plan of improvement that was selected for Sherwood Island State Park considered level beach berm widths of 200, 225, and 250 feet. The factors used in considering the best possible solution focused on the geographical and geological features; the storm, tidal, and wave processes; park use needs; economics; and environmental effects.

A storm stage frequency analysis was conducted to determine a berm elevation that would provide protection against a storm frequency of once in two years.

Based on this analysis, a maximum beach berm elevation of 12.0 feet above the mean high waterline was selected. This design will contribute to the needs of the area along with the regional economic development and social well-being of the area. Groin structures were designed to consider the predominant direction of littoral drift, to compartmentalize the sandfill, and to stabilize the beach. A study was completed using shoreline change maps, aerial photographs, and surveys where it was determined that the predominant direction of littoral transport was alongshore in a westerly direction and not onshore and offshore. From this analysis, the placement of sandfill with groin structures and periodic nourishment was the most feasible method to protect and restore the shore. A comparison of the cost and benefits of the alternative plans can be found in the System of Accounts, Table 2-1. The analysis of benefits and costs procedure for the four plans of protection can be found in Appendix 8, titled "Economics."

The beach development plan that will provide substantial economic benefits and create minimal environmental impacts is Plan 3, which consists of the following:

> The direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, lowering the landward end of the existing Federal groin structure, and constructing a low-profile groin structure located approximately 900 feet west of Sherwood Point.

This plan provides for the development of a 200-foot level beach berm at elevation 12.0 feet mean low water (MLW) as well as an average beach width above the mean high waterline of approximately 275 feet. The front face of the beach berm will have a 1 vertical on 15 horizontal slope to the existing bottom. Approximately 90,000 cubic yards of sandfill, including the first year of periodic nourishment, would be required initially at a first cost of $960,000. This includes the cost of groins and excavation. These costs include both Federal and non-Federal costs. Periodic nourishment is estimated to be 3,000 cubic yards per year at an estimated annual cost of $21,000. In addition, the State of Connecticut will be required to sign local assurances as stated in the recommendations portion of the main report.

SUMMARY DISPLAY OF EFFECTS

The beneficial and adverse impacts for the four considered plans of improvement and their contributions to the NED, EQ, RED, and OSE accounts are listed in Table 2-1, System of Accounts. The analysis considered the aesthetics of the area, shore alignment, recreational facilities, and shore protection. The proposed plan of improvement includes a low-profile groin structure which would improve the aesthetics of the area by reducing

sandfill losses. This reduction in sandfill losses would also contribute to the continued recreational use of the beach and the protection of the backshore.

Continued contact throughout the course of the study was maintained with Federal and State fish and wildlife groups, and the following State agencies: Department of Environmental Protection, State Department of Parks and Recreation, Coastal Zone Management, as well as local interests. Coordination with these groups resulted in a selected plan that meets the needs of the area.

CORPS OF ENGINEERS, NED

TABLE 2 - 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNTS	**FOOTNOTES	*PLAN 1		
1. National Economic Development (NED)				
a. Beneficial Impacts (Annual)				
Increased Recreation				
200' Berm	2,5,7,9	$697,000		$
225' Berm	2,5,7,9	$767,000		$
250' Berm	2,5,7,9	$867,000		$
Recreational Fishing	2,5,7,9	N/A		
Prevention of Loss of Land	2,5,7,9	21,600		
b. Project Costs (Annual)		**Federal**	**Local**	**Fe**
200' **Berm**		$ 72,000	$31,000	$7
225' **Berm**		$118,000	$50,500	$11
250' **Berm**		$188,000	$80,500	$18
Non-structural plan				
(1) Total NED Costs (Annual)				
200' **Berm**		$103,000		$1
225' **Berm**		$168,500		$1
250' **Berm**		$268,500		$2
Non-structural plan		N/A		
c. Net NED Benefits (Annual)				
200' Berm		$615,600		$6
225' Berm		$620,100		$6
250' Berm		$620,100		$6
Non-structural plar		N/A		
d. Benefit-Cost Ratio				
200' Berm		6.98		
225' Berm		4.68		
250' Berm		3.31		
Non-structural plan		N/A		

1 Applies to each berm

TABLE 2 - 1
SYSTEM OF ACCOUNTS
RWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLAN 1		*PLAN 2		*PLAN 3		*PLAN 4	
						1,500	
$697,000		$704,200		$704,200		N/A	
$767,000		$774,900		$774,900		N/A	
$867,000		$875,900		$875,900		N/A	
N/A		N/A		9000[1]		N/A	
21,600		21,600		21,600		2,500	
Federal	**Local**	**Federal**	**Local**	**Federal**	**Local**	**Federal**	**Local**
$ 72,000	$31,000	$72,500	$31,000	$65,800	$29,200	N/A	N/A
$118,000	$50,500	$118,000	$51,000	$104,000	$49,000	"	"
$188,000	$80,500	$188,500	$80,500	$157,000	$79,000	"	"
						$7,500	$3,200
$103,000		$103,500		$ 95,000		N/A	
$168,500		$169,000		$153,000		"	
$268,500		$269,000		$236,000		"	
N/A		N/A		N/A		$10,700	
$615,600		$622,300		$639,800		N/A	
$620,100		$627,500		$652,500		"	
$620,100		$628,500		$670,500		"	
N/A		N/A		N/A		0.0	
6.98		7.01		7.73		N/A	
4.68		4.71		5.26		"	
3.31		3.34		3.84		"	
N/A		N/A		N/A		.37	

[1] Applies to each berm width.

2

TABLE 2 - 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNTS	**FOOTNOTES	*PLAN 1	
2. Environmental Quality (EQ)			
a. Beneficial Impacts			
(1) Restoration of Valuable Beach using Sandfill from land source	2,6,9	yes	
(2) Protection of Recreational Facilities (New groins and sandfill will protect beach from erosion)	2,6,9	yes	
(3) Provision of Recreational Beach Area (Sandfill will provide increased beach area)	2,6,9	yes	
(4) Provision of Fishing Facilities (New groin structures)	2,6,9	no	
(5) Prevention of Littoral Sand Drift (New groin structures)	2,5,9	no	
b. Adverse Impacts			
(1) Archaelogical/Historical Resources		no impact	no
(2) Air Quality (Degraded temporarily due to construction activities; i.e., dust, emissions, etc.)	1,5	Minor-temporary	[illegible]
(3) Noise (Increased due to construction; fill transport by trucks)	1,6	Minor-temporary	[illegible]

TABLE 2 - 1
SYSTEM OF ACCOUNTS
RWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
yes	yes	yes	no
yes	yes	yes	no
yes	yes	yes	yes
no	no	yes	no
no	no	yes	no
no impact	no impact	no impact	no impact
Minor-temporary	Minor-temporary	Minor-temporary	no
Minor-temporary	Minor-temporary	Minor-temporary	no

2

TABLE 2 - 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNTS	**FOOTNOTES	*PLAN 1	
(4) Water Quality (Increases in turbidity during fill and construction activities may cause short-term decrease in the oxygen level in the water)	1,6	Minimal decrease in DO levels	Mi de DO
(5) Benthic Organisms (Any organisms unable to evacuate the areas to be filled will be destroyed)	1,5	yes	
3. Social Well-Being			
a. Beneficial Impacts			
Effects on Desired Community Growth	2,5,8,9	Compatible with loc and improve recreat	
Effects on Educational, Cultural, and Recreational Opportunities	2,5,8,9	Increase recreation with increased capa	
b. Adverse Impacts			
Community Disruption	1,6,9	Temporary disruptio	
Effects on Health, Safety, and Community Well-Being	1,6,9	Temporary threat du on local roads and project site.	

TABLE 2 - 1
SYSTEM OF ACCOUNTS
ERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
Minimal decrease in DO levels	Minimal decrease in DO levels	Minimal decrease in DO levels	No effect expected
yes	yes	yes	no
Compatible with local land use plans to improve Sherwood Island State Park and improve recreational facilities.			
Increase recreational opportunities by providing additional dry beach space with increased capacity.			
Temporary disruption during construction; site specific disruptions			
Temporary threat during construction on local roads and areas at or near project site.			N/A

2

TABLE 2 - 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

ACCOUNTS	**FOOTNOTES	*PLAN 1	*P
4. Regional Development			
a. Beneficial Impacts			
Effect on Regional Recreational Activity	2,5,9	Increase salt water based recreational opportunities	sa
Effects on Employment	1,6,7,9	Use of local labor pool fo	
Effects on Local Commercial and Industrial Activities	2,4,9	Probable increase in busin resulting from increased r	
b. Adverse Impacts			
Effects on Public Services	2,5,9	Possible need for increase	
Effects on Public Facilities	2,5,9	No effect	No

TABLE 2 - 1
SYSTEM OF ACCOUNTS
ERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLAN 1	*PLAN 2	*PLAN 3	*PLAN 4
Increase salt water based recreational opportunities	same as 1	same as 1	No effect
Use of local labor pool for construction of project.			
Probable increase in business for local establishments resulting from increased number of beach of beach users.			No effect
Possible need for increased police and lifeguarding services.			No effect
No effect	No effect	No effect	No effect

∂

TABLE 2- 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

*PLANS

Considered Plans of Improvement: Each of the bealow plans consisting of sandfill will include 3 different level beach berms (200, 225, and 250 feet wide).

Plan 1 - Beach widening by direct placement of suitable sandfill along approximately 1,C00 feet of shoreline extending east from the existing Federal groin structure.

Plan 2 - Same as Plan 1 plus placing rock revetment at Sherwood Point and lowering the landward end of the existing groin structure located at the west limit of the study.

Plan 3 - Same as Plan 2 with an intermediate low-profile groin structure located between Sherwood Point and the west limit of the study.

Plan 4 - Shore management planning guidelines. This plan involves managing the use of the backshore facilities. This plan includes restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dunes.

**FOOTNOTES

Timing

1. Impact
2. Impact
3. Impact implemen

Uncertainty

4. The unc
5. The unc
6. The unc

Exclusivity

7. Overlap
8. Overlap

Actuality

9. Impact
10. Impact during
11. Impact

1/ Easily impact

TABLE 2- 1
SYSTEM OF ACCOUNTS
SHERWOOD ISLAND STATE PARK
WESTPORT, CONNECTICUT

**FOOTNOTES

Timing

1. Impact is expected to occur prior to or during implementation of the plan.
2. Impact is expected within 15 years following plan implementation.
3. Impact is expected in a longer time frame (15 or more years following implementation.)

Uncertainty 1/

4. The uncertainty associated with the impact is 50% or more.
5. The uncertainty is between 10% and 50%.
6. The uncertainty is less than 10%.

Exclusivity

7. Overlapping entry; fully monetized in NED account.
8. Overlapping entry; not fully monetized in NED account.

Actuality

9. Impact will occur with implementation.
10. Impact will occur only when specific additional actions are carried out during implementation.
11. Impact will not occur because necessary additional actions are lacking.

1/ Easily reversible measures are desirable in cases where uncertainty of impact is high.

2

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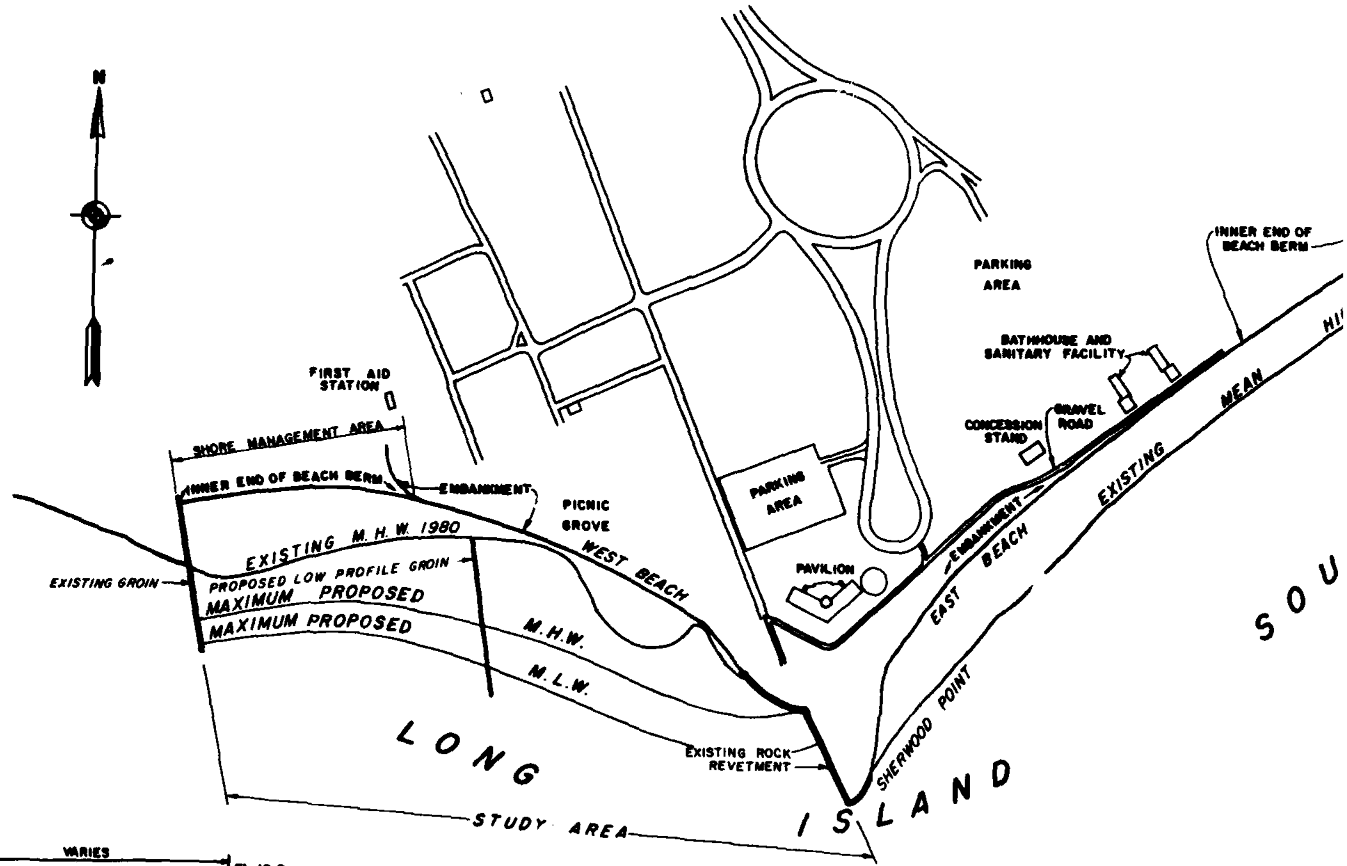
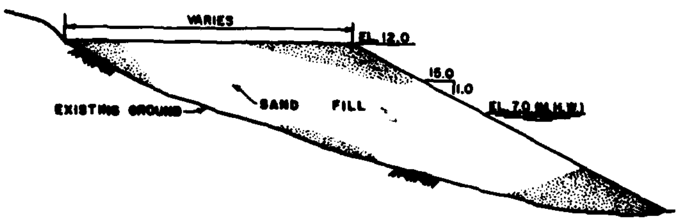
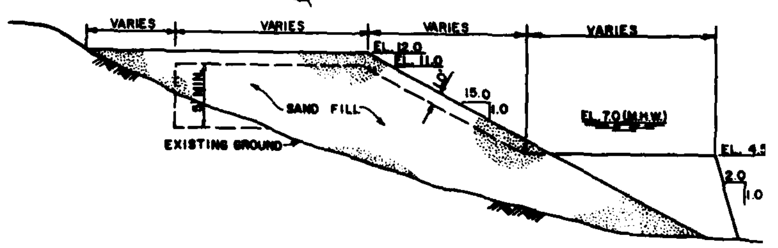
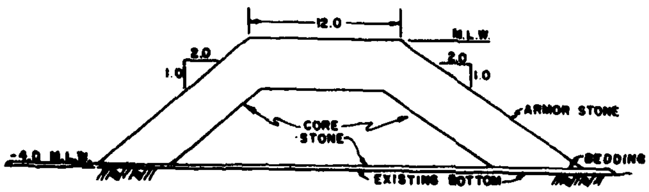




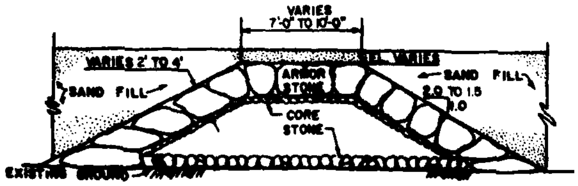
TYPICAL PROFILE
SANDFILL
SCALE



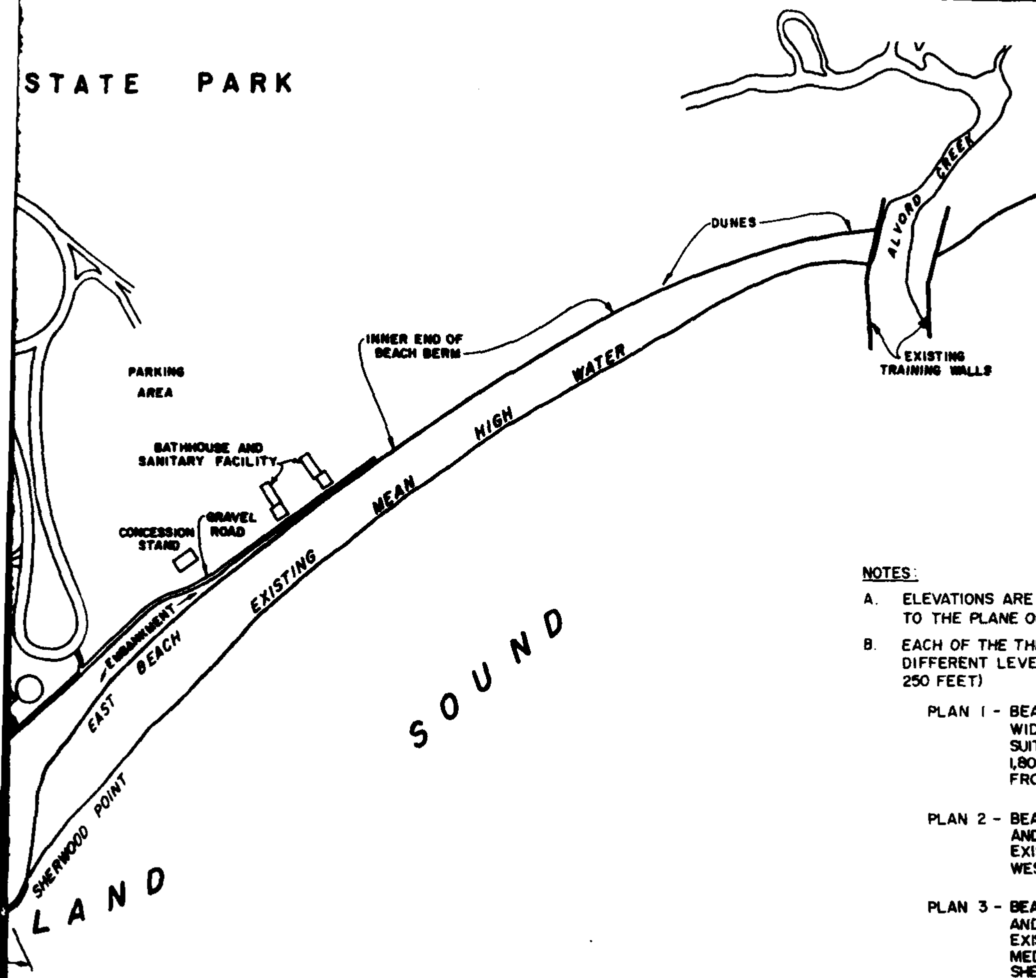
TYPICAL PROFILE
LOW PROFILE GROIN
SCALE



TYPICAL SECTION
OFFSHORE STONE BREAKWATER
NOT TO SCALE



TYPICAL SECTION
LOW PROFILE GROIN
SCALE



NOTES:

A. ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERRED TO THE PLANE OF MLW.

B. EACH OF THE THREE PLANS BELOW WILL INCLUDE THREE DIFFERENT LEVEL BEACH BERM WIDTHS (200, 225 AND 250 FEET)

PLAN 1 - BEACH WIDENING, TO A LEVEL BEACH BERM WIDTH, BY THE DIRECT PLACEMENT OF SUITABLE SANDFILL ALONG APPROXIMATELY 1,800 FEET OF SHORELINE EXTENDING EAST FROM THE EXISTING FEDERAL GROIN STRUCTURE.

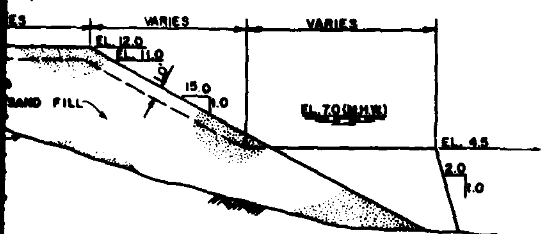
PLAN 2 - BEACH WIDENING TO A LEVEL BEACH BERM WIDTH, AND LOWERING THE LANDWARD END OF THE EXISTING GROIN STRUCTURE LOCATED AT THE WEST LIMIT OF THE STUDY AREA.

PLAN 3 - BEACH WIDENING TO A LEVEL BEACH BERM WIDTH AND LOWERING THE LANDWARD END OF THE EXISTING GROIN STRUCTURE, AND PLACING AN INTERMEDIATE LOW-PROFILE GROIN STRUCTURE BETWEEN SHERWOOD POINT AND THE WEST LIMIT OF THE STUDY AREA.

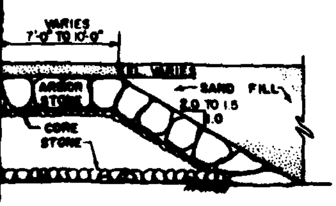
C. PLAN 4 - SHORE MANAGEMENT PLANNING GUIDELINES.

D. PLAN 5 - OFFSHORE BREAKWATER LOCATED APPROXIMATELY 600 FEET OFFSHORE, FRONTING THE WEST BEACH.

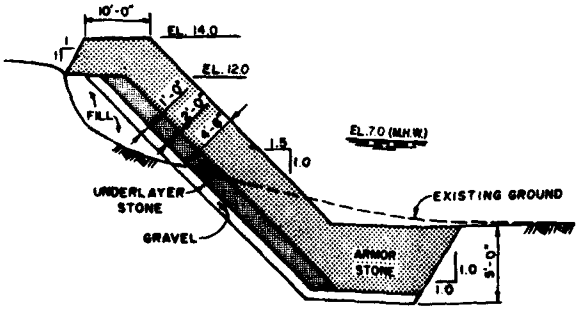
E. PLAN 6 - ROCK REVETMENT PLACED ALONG THE ENTIRE LENGTH OF THE BACKSHORE OF WEST BEACH EXTENDING BETWEEN THE EXISTING WEST GROIN STRUCTURE AND SHERWOOD POINT.



TYPICAL PROFILE
LOW PROFILE GROIN
SCALE



TYPICAL SECTION
LOW PROFILE GROIN
SCALE



TYPICAL SECTION
ROCK REVETMENT
NOT TO SCALE

2

BEACH EROSION CONTROL STUDY
SHERWOOD ISLAND
WESTPORT, CONNECTICUT
PLANS OF
CONSIDERED IMPROVEMENT

200' 0 200' 400'

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

APPENDIX 3

PUBLIC VIEWS AND RESPONSES

PUBLIC VIEW AND RESPONSES

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PUBLIC VIEWS AND RESPONSES

INTRODUCTION

Public participation in beach restoration and protection projects that generate public benefits and require that expenditures of public funds begin with public involvement. Because of the complex process involved in developing the most practical and economical method of restoring the shore, initial public involvement is restricted to Federal, State, local, and selected interest groups and not always to the general public. It has been our policy to have regular meetings with small groups of local officials from various environmental and social groups, through the course of the study, to assist us in formulating the considered plans of improvement. During the late stages of the report, an official public notice and press release is issued informing everyone of the Environmental Impact Assessment and asking for formal comments on the proposed plans of improvement. Following this, after any comments are received and reviewed and the final plan has been selected, a formal public meeting is held if deemed necessary. In the case of Sherwood Island, West Beach, a formal public meeting was waived in lieu of the 30 June 1981 walk/talk workshop meeting held on the beach. This meeting was very well received and from the feedback we received, it was found very effective.

Inclosed in this section of the report is all of the pertinent correspondence from the beginning of this report through the final public walk/talk workshop. The Federal fisheries were the only objectors to the proposed plans of protection considered or to the recommended plan. All comments obtained from the walk/talk public workshop were positive and in favor of the proposed plan. Below is a list of meeting dates that were held with city, State and local officials throughout the course of the study.

9 February 1981 -	Mr. Miller, Chief Park and Recreation: State of Connecticut.
5 March 1981 -	Selectman Office - Westport, Connecticut, and Town Officials.
29 April 1981 -	Sherwood Island State Park Pavillion - State and Federal Fish and Wildlife, oystermen, and other concerned citizens.
2 May 1981 -	Compo Cove Beach Association, Westport, Connecticut - Messers Leach, State Dept., and Bruha made a brief presentation to 40 Compo Cove and Westport property owners at the association presidents' beach house.

21 May 1981 - Mr. Robert Leach, State Dept., presented the State and Federal beach erosion control improvement to the Westport, Connecticut, Conservation Commission. Mr. Leach indicated to me that there were no major problems or objections to either project.

30 June 1981 - Walk/Talk information public meeting and workshop at Sherwood Island State Park Pavillion. The recommended plan of improvement as well as other plans considered were discussed. A beach walk followed a brief informal meeting.

These meetings along with numerous field visits before, during and after storms enables us to arrive at a better understanding of the shoreline process for the beach and adjacent shore area.

ELLA GRASSO
GOVERNOR

STATE OF CONNECTICUT
EXECUTIVE CHAMBERS
HARTFORD

January 19, 1979

Colonel John P. Chandler
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Chandler:

In earlier correspondence I have requested the Corps' assistance in the development of Silver Sands State Park in Milford, Connecticut.

I have been informed by Commissioner Stanley J. Pac of the Department of Environmental Protection that as a part of the state's ongoing program of beach improvements, it would be desirable to complete the shore erosion project at Sherwood Island State Park in the Town of Westport. I am, therefore, requesting the Corps' assistance to bring this project to a conclusion.

It has been my intention since assuming office to provide the citizens of Connecticut the best possible shore line facilities for recreational purposes. The stabilization of the beach at Sherwood Island and the development of Silver Sands State Park represent a substantial achievement toward this objective.

Commissioner Pac is responsible for the overall project and it is my understanding that the project officer for the beach development will be Richard Clifford of the DEP's Park and Recreation Unit. Mr. Clifford can be reached at (203) 566-2304.

I wish to thank you for your interest in this project and look forward to cooperatively bringing it to a successful conclusion.

With best wishes,

Cordially,

Ella

ELLA GRASSO
Governor

It was good of you to come to our meeting and help with the N.H.-Stamford problem - EG

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NEDPL-C	Trip Report - Sherwood Island State Park, Westport, Ct

TO	FROM	DATE	CMT 1
Memorandum For the Record	Project Manager	10 February 1981	

1. On 9 February 1981, Cathy LeBlanc and Messrs. Doucakis and Bruha met with the State of Connecticut Department of Parks and Recreation in Hartford, CT, to discuss the Sherwood Island State Park beach plan of improvement. Also attending the meeting were Mr. William Miller, Director of Parks and Recreation; Mr. Dick Clifford, engineer; and Mr. Stan Bates, engineer.

2. The undersigned discussed the project and the alternate plans of improvement. At this stage of the study a detailed cost analysis has not yet been completed but preliminary numbers were discussed. It was also mentioned that as part of the design the inner end of the existing Federal groin structure located at the west limit of the study would be lowered 1½-2 feet along the backshore. This was because the proposed sandfill will be at El. 12.0 feet MLW and the structure is presently at El. 15.0 feet MLW along the backshore. Therefore, a one-foot freeboard would be satisfactory to compartmentalize the sand-blown sand. Mr. Miller had no objections to this suggestion. He also had no objections to the suggestion that material of a poorer grain size from Compo Pond could be used as a base provided that a better grade of material would be placed over this material. Consideration is being given to this method of construction. A final decision will be made by Engineering Division and with cooperation of the State of Connecticut.

3. They were also informed that a meeting would be scheduled with the town of Westport officials to discuss the proposed plan and that the State would be invited to attend.

4. The meeting adjourned with the understanding that we would keep Mr. Miller and the Recreation Department informed of our actions as we proceed with finalizing our plans. His office would also receive copies of the draft Detailed Project Report for review and comment prior to finalizing the report.

5. The meeting was informative and there was also a good exchange of ideas and information. Everyone concerned with the project on the State level agreed that the proposed plans considered should be helpful and we should proceed on schedule.

T. Bruha
BRUHA

Appendix 3
3-4

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NEDPL-C	Trip Report - Sherwood Island State Park, Westport, CT

TO Division Engineer FROM Project Manager DATE 11 March 1981 CMT 1
Mr. Bruha/mc/554

Thru: Channels

1. On 5 March 1981 Mr. Bruha and Dr. Fessenden attended a meeting in the First Selectman's office in Westport, Connecticut. The purpose of the meeting was to familiarize the officials of the town of Westport with the proposed Sherwood Island State Park beach erosion control project. A list of persons attending the meeting is inclosed.

2. The undersigned opened the informal meeting by discussing the project and the considered plans of improvement. The meeting immediately became an open, informational discussion of questions and answers.

3. Dr. Frank Fessenden was then asked to briefly discuss the geological aspects of the study and to describe the impacts on the area as a result of the proposed improvement.

4. Mr. Robert Leach of the State of Connecticut Department of Environmental Protection, Hartford, CT, who is presently in charge of writing the Environmental Impact Evaluation for the State of Connecticut that will be used as the Corps' EIS, proceeded to outline what the State is proposing to do along the adjacent private shoreline. He also discussed source of sand and construction procedure that they will be using in providing the usable dry beach along the private sector of shoreline west of Sherwood Island.

5. The meeting was open and very informative. Everyone present felt that the Sherwood Island project was essential to the State and that the town was in favor of the project. They would like to see additional material removed from Compo Cove and would like to see the Corps use it at Sherwood Island. We are presently looking into this as a possible underlayer or base with 3-5 feet of a more suitable material covering this lesser quality material. The State is presently conducting a study with a private consulting firm that will sample the material in this offshore area to determine if the material is clean and suitable for beach use. This information should be available to us some time in the summer of 1981.

6. Mrs. Heneage, First Selectwoman, stated that she thought that there would be little or no objections from the town to either the State or the adjacent private shore protection projects. The meeting adjourned on the note that we would keep the town informed as to the progress of the report, and during the review period the town would have an opportunity to comment on the proposed and final plans of improvement.

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

NEDPL-C 11 March 1981
SUBJECT: Trip Report - Sherwood Island State Park, Westport, CT

7. Import/Impact on NED: As a result of this meeting we now feel that we have the cooperation of the town of Westport and we can proceed with finalizing the Detailed Project Report.

T Bruha
BRUHA

Incl
as

cc: Coastal Dev. Br.
Planning Div. File

NAME

Thomas C. Bruha
Dr. Frank Fessenden
J. Heneage
Boldin B. Lee
R.H. Leach
G.J. Smith
Jack Forebrand
Fran Pierwola
Dorothy Williams
Mel Barr

ORGANIZATION

NED/Coastal Dev. Br.
NED/Coastal Dev. Br.
First Selectwoman, Westport
Recreation, Westport
CT Dept. of Env. Protection
Westport Public Works
Recreational Comm.
Conservation Director
1st Selectman's Adm. Asst.
Planning Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. Box 1518
Concord, New Hampshire 03301

Colonel William E. Hodgson
Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

MAR 11 1981

Dear Colonel Hodgson:

This letter is intended to aid in your study of possible beach restoration measures at Sherwood Island State Park, Westport, Fairfield County, Connecticut. It has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The current study is being limited to West Beach which extends from Sherwood Point about 1,800 feet westerly to an existing Federal groin. The rock and cobble shoreline at Sherwood Point grades into the sandy West Beach about 400 feet west of the point and extends about 1,400 feet to the groin.

Fish and wildlife consist of fish and shellfish resources in the intertidal and subtidal area. Waters off the beach are shallow, ranging to three feet below mean low water a few hundred feet from shore. The sandy beach above high water, the lawn, picnic grove and parking lot typical of the Park area have little fish and wildlife value except that the lawn is extensively grazed by Canada geese wintering in nearby wetlands.

The intertidal and subtidal areas support shellfish, crustacea, and other benthic and burrowing organisms which are harvested by man (recreational and commercial oyster harvesting) or fed upon by fish, shorebirds and waterfowl. The most productive areas are those where rocks and cobbles form islands of relatively stable, hard surfaced, habitat. Sandy areas are far less productive.

Sherwood Point is the apex of a number of boundary lines marking oyster lots. There are 32 lots extending generally offshore from Sherwood Point and west toward Cedar Point. The inshore boundary lies less than 1,000 feet from West Beach. 1/

Placing sand on the sandy section of West Beach would have little positive or adverse benefit to fish and wildlife resources if fill in the subtidal area is avoided. We suggest that the new sand be placed so as to maintain

1/ Connecticut Shell Fish Commission (now Aquaculture Division of the Department of Agriculture). Map of Norwalk and Westport Town Oyster Grounds, June 1980.

the existing, natural curve of the beach. Since preventing loss of sand from this beach is the main objective, a straight shoreline may be less stable than curved beach. Placing the sand above mean low water should reduce potential benthic changes in subtidal areas.

Removal of sand from Compo Cove for use on West Beach should not have serious adverse impacts on resources in the Cove. Studies of the benthic community in the Cove, and of possible changes in Sherwood Millpond, will be necessary to verify potential impacts.

Construction of an additional groin at the east end of the beach is part of Plan 3. Constructing this groin would destroy benthic habitat. However, any cobble bed destroyed would be replaced by the niches created in the stone surface of the groin. There could be some enhancement of habitat where the groin is constructed on sand, which is a less productive surface. The groin also would provide additional access for fishermen.

Reducing the top elevation of the inshore end of the existing groin would have little effect upon fish and wildlife resources in the study area. If this proposal is implemented and achieves its purpose of allowing wind blown sand to move westward it should have little impact upon fish and wildlife. If this measure accelerates sand deposition in Compo Cove it would have some adverse impacts in contributing to the instability of the benthic habitat. Depositing sand on the cobble and rocky areas of this beach should be avoided.

Construction of an offshore breakwater would destroy benthic habitat but we believe this habitat would be replaced if the breakwater is constructed with a rough, stone surface. Loss of clam habitat, however, would not be replaced because clams would not inhabit the stones of the breakwater.

Construction of a rock revetment along the backshore between Sherwood Point and the existing groin would have little impact upon fish and wildlife resources.

Additional studies should include a detailed benthic survey of any subtidal or intertidal area that will be subject to a habitat change, such as from cobble to sand. The amount and kind of mitigation required cannot adequately be determined without this information.

There is no outstanding choice for fish and wildlife benefits among the alternate plans nor is it evident that any particular plan will cause significant losses. Additional information about specific resources to be impacted will be needed to refine our conclusions. Plan 3, which includes a new groin, seems to have more potential for providing additional benefits in the form of fishing space. Also, the "no action" plan would have little impact except that for the possibility that erosion of the Point will continue and the material will end up in Compo Cove.

Please advise us when you select the plan that will be recommended so that we can evaluate it and prepare a final report.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
New England Area Office
P. O. Box 1518
Concord, New Hampshire 03301

MAR 11 1981

Colonel William E. Hodgson
Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Hodgson:

We are sending you endangered species information to assist you in planning for the beach erosion study at Sherwood Island State Park in Connecticut.

Our review shows that except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further consultation is required with us under Section 7 of the Endangered Species Act. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our concerns under the Fish and Wildlife Coordination Act.

Sincerely yours,

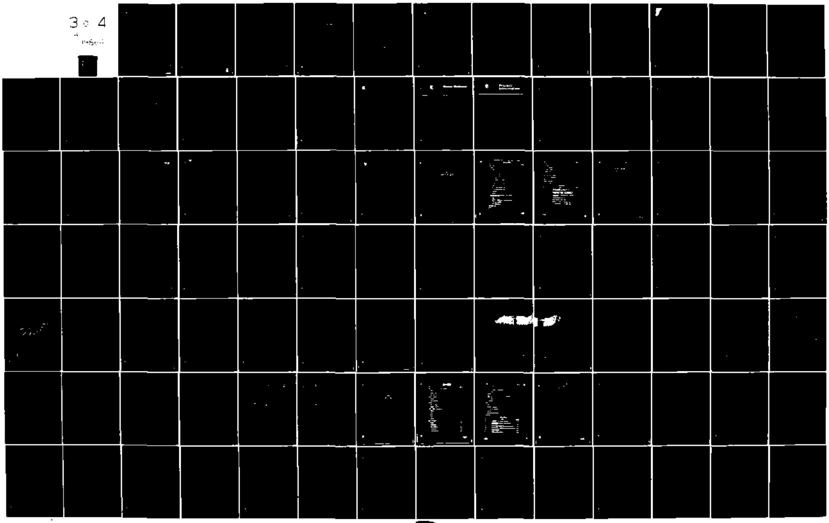
Gordon E. Beckett

Gordon E. Beckett
Acting Area Manager

AD-A110 869 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 13/2
WEST BEACH, WESTPORT, CONNECTICUT, SHERWOOD ISLAND STATE PARK. --ETC(U)
SEP 81

UNCLASSIFIED NL

3 of 4



WESTPORT CONNECTICUT

OFFICE OF THE FIRST SELECTMAN

3

March 19, 1981

Colonel C. E. Edgar, III
Division Engineer
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

Dear Colonel Edgar:

This is to inform you that the town of Westport, Connecticut, approves of the U.S. Army Corps of Engineers' proposed beach erosion control project at Sherwood Island State Park. Mr. Thomas Bruha and Dr. Frank Fessenden of your Coastal Development Branch, at a meeting on 5 March 1981 in my office, explained in detail the Sherwood Island study. At this time we were also informed by Mr. Robert Leach of the State of Connecticut Department of Environmental Protection of the proposed planning effort and work that the State will be doing on the private beach in Compo Cove in conjunction with your project.

It is my feeling that the Park is essential to the recreational needs of Westport and the surrounding cities and towns. Therefore, I support your effort in this matter.

In the very near future I will be requesting assistance from your office on two other publicly-owned beaches that over the years have been overtopped and are eroding.

Sincerely,

J Heneage

Jacqueline P. Heneage
First Selectman

JPH:hml

CC: Gerard Smith
Director of Public Works
Thomas Bruha
Chief, Beach Erosion Section

Vanucci

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Services Division
Habitat Protection Branch
7 Pleasant Street
Gloucester, Massachusetts 01930

MAY 7 1981

Col. C.E. Edgar, III
Division Engineer
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Edgar:

The National Marine Fisheries Service (NMFS) has reviewed the information which accompanied Mr. Ignazio's letter of April 20, 1981, regarding the Section 404(b) Factual Determination and Finding of Compliance for the proposed Beach Erosion Control Project at Sherwood Island State Park, Westport, Connecticut.

NMFS takes exception to several statements made in the Factual Finding and subsequently reiterated in the Public Notice. Of major concern is the statement that there are no known significant shellfish resources in the area which would be affected by the project. 1 [This statement was apparently made without New England Division knowledge of the sediment characteristics or potential for impact of the material from Compo Cove or unidentified upland borrow area(s).] 2 [It also appears that the presence of natural beds of hardclams (Mercenaria mercenaria) and commercially operated oyster (Crassostrea virginica) beds at Sherwood Island were not considered. As we have previously reported, those resources are present and could experience an adverse impact from project implementation.] [This conclusion is based 3 upon the work of Sherk[1] (1972) who reported that suspended sediment does adversely affect spawning and setting.

4 [It is also stated in the Factual Finding that the proposed fill material will be compatible with existing sediments. Since much of West Beach at the park is a cobble-stone substrate, this statement is inaccurate. Building on this initial inaccuracy the Factual Finding states that the habitat will not be altered by expanding the beach to a width of 325 feet above mean high water. Such a conclusion lacks appreciation for the habitat provided by the existing cobble beach and the signicicant difference that a sand beach will offer. It also fails to recognize that the new beach will be subject to storm mobilization as well as daily, induced, littoral processes. Both of the forces can be excepted to actively erode the beach face.]

---

[1]Sherk, J.A. 1972. Current status of knowledge of the biological effects of suspended and deposited sediment in Chesapeake Bay. Taxa and special effect summaries. Contrib. No. 515, Univ. Md., Nat. Res. Inst. 5137-5144.

8 MAY 1981

5 A brief review of the creation of Sherwood Island Park reveals that the beaches were "enhanced" during construction in the mid 1950s. The Compo Cove area has been found to be the ultimate recipient of most of that "enhancement" material. Since the forces which induced the migration initially are not to be altered, we assume that they will continue to move sand westerly along the shoreline. In view of this prevailing situation it is inappropriate to conclude that no persistent impacts will be experienced. We suggest that the loss of stability along the beach, the migration and ultimate deposition of the fill will act to degrade the quality of life in this area for years to come.

6. As noted in the previous paragraph, the forces at work along West Beach will not be altered by the proposed action. A 490 foot long groin is proposed for West Beach to "help to compartmentalize the beachfill". It would, according to your press release of April 20, 1981, "not prevent natural forces from nourishing other beach areas". Sherwood Point is the beginning of the westward drift pattern for this area. Beaches further inside Compo Cove must get their nourishment from West Beach. Therefore, we assumed that your staff assessed this situation and were able to recommend a low profile structure. Prior to development of plans and specifications, however, we would appreciate an opportunity to review length, alignment, height, general design and utility of this 5,000 ton structure as it appears to perform two tasks which are at odds with each other; the allowance of natural motion of sand and the compartmentalization of West Beach.

7. The fill material, if obtained from an upland source, will not be as well sorted as littorally drifted beach sand. The exposure of those new and unsorted sediments to wave wash will elevate turbidity levels in the general area. Because of the availability of fine sediment sizes, turbidity plumes can be expected to have some persistence. The Factual Determination conclusion is at odds with our statement because it addresses only the large particle sizes of the fill. We suggest a reconsideration of that statement by your staff.

8 Reducing the retentive ability of the westernmost groin can be expected to act as an additional destabilizing force on the beach. Studies in New York, New Jersey and Florida have shown that aeolian forces do move sand; however, the volume involved is significantly less than by aquatic forces. The effect of storm elevated seas on that lowered groin will have, however, major impacts on downdrift properties. This consideration is not broached in the present assessment documentation. It should be.

9 Finally, we are curious as to why the Corps plans to fill only offshore area to create the desired beach width. (Incidentially, what importance does the six foot depth of fill figure have to the project?) The fetch of the area and shoreline orientation dictate that westerly migration of the fill will occur. As noted above the history record of the beaches supports this conclusion. In view of those findings, why not place sand on the existing upland as well as offshore? This would create the desired beach width while minimizing the extent of the offshore encroachment.

In view of the conclusions we have drawn, NMFS urges that the entire project be reassessed and hopefully redesigned to take advantage of the natural forces at work at Sherwood Island State Park. We also recommend that the support documentation be rewritten to more accurately discuss the existing environment and the potential impacts associated with implementing the selected course of action at this location.

Sincerely,

for [signature]
Ruth Rehfus
Acting Branch Chief

Office of the
STATE
HISTORIC
PRESERVATION
OFFICER
for Connecticut

RECEIVED
MAY 1 3 1981
OFFICE OF
POLICY & MANAGEMENT
Division of Comprehensive Planning

59 SOUTH PROSPECT STREET - HARTFORD, CONNECTICUT 06106 - TEL: (203) 566-3005

May 7, 1981

State Clearinghouse Director
Office of Policy and Management
80 Washington Street
Hartford, Connecticut 06115

Subject: Beach Erosion Control Project,
Sherwood Island State Park,
Westport, CT.

Dear Sir:

The State Historic Preservation Officer has reviewed the above named project. In the opinion of the State Historic Preservation Officer, this project will have no effect on historical, architectural or archeological resources listed on or eligible for the National Register of Historic Places.

Sincerely,

John W. Shannahan
State Historic Preservation Officer

DAP/dmd

Appendix 3
3-16

STATE HISTORIC PRESERVATION OFFICER: The person responsible for implementation in Connecticut of the National Historic Preservation Act of 1966 administered by the Department of the Interior, Heritage Conservation and Recreation Service, Washington, D.C.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. Box 1518
Concord, New Hampshire 03301

Colonel William E. Hodgson
Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

MAY 12 1981

Dear Colonel Hodgson:

These comments are submitted in response to Mr. Ignazio's letter dated April 20, 1981, concerning Section 404(b) Factual Determination, Finding of Compliance and Public Notice for Sherwood Island State Park, Westport, Connecticut.

The Public Notice mentions that an Environmental Assessment will be completed by June 1981. We have been advised that project documents showing the area of fill and its relationship to the intertidal zone will be completed at about the same time. This information, which should show the area of intertidal zone to be filled and the probable future changes in the beach, is needed to evaluate the environmental impact. Our final report will be submitted as soon as we receive this information. These comments do not constitute a report and they are provided to assist you in project planning.

Paragraph 4 of the Factual Determination and Finding of Compliance briefly relates environmental concerns. We suggest that this section should be expanded to include a description of the habitat types (sand beach, cobble beach, etc.), the benthic species, and the commercial oyster leases just offshore. This section should include information on the impacts of sand deposition at other locations in Compo Cove or offshore and estimates of the historical changes in the beach.

Paragraphs 4c and 230.11(a) state that fill material (sand) will be compatible with existing sediments. We cannot agree because the sand fill will cover a beach that is now mostly cobble at lower elevations. The sand that was there in the past has washed away. An estimate of the annual and long term patterns of sand movement would be helpful in evaluating the impacts.

Section 7b mentions that appropriate measures for reducing adverse impacts are listed in the Environmental Assessment to be issued later. We suggest that a brief description of these measures should be included in this section.

Paragraph 230.11(e) continues the discussion about impacts assuming that the substrate will remain the same and that the same benthic communities will be re-established. Not only will some of the substrate change from cobble to sand when the project is done, it will continue to change as this beach undergoes the dynamic changes common to such sites. An assessment of the future change is needed.

Secondary impacts are considered in paragraph 230.11(b). We suggest that the potential impact of the deposition of sand lost from the new beach should be included in this section. This should include offshore and alongshore movement.

In conclusion, we feel that the 404(b) documents are not complete without insertion of additional details about the construction plans and the environmental impacts with and without the project so that impact assessment can be facilitated. Perhaps the 404(b) documents should be released for review at the same time as the environmental assessment and project details. The change from productive cobble to less productive sand would be a loss that will be hard to mitigate. Avoiding the loss is always the best solution and we feel that moving the fill shoreward would result in less intertidal filling, less environmental loss, and perhaps less sand loss from wave action.

The documents use the word "not significant" in describing the environmental impacts, but without data, such as square feet of cobble habitat changed to sand habitat, the word has little meaning. We are suggesting that the environmental impacts should be more clearly defined so that the magnitude of the impact can be adequately described. The documents lack information needed to evaluate the impact as required in 40 CFR Part 230.4-1(a)(3).

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor

WESTPORT CONNECTICUT
CONSERVATION COMMISSION
TOWN HALL-110 MYRTLE AVENUE
WESTPORT, CONNECTICUT 06880

May 21, 1981

Robert Leach
State of Connecticut, DEP
Water Resources Unit
State Office Building
Hartford, CT 06511

RE: Shore Erosion Project
Westport/Compo Cove
Sherwood Island

Dear Bob:

The Westport Conservation Commission and Staff truly appreciate the cooperative effort you have shown by making an informative presentation on the above at our meeting of May 20, 1981.

We extend to you our sincere thanks and appreciation for your sincere input in this matter and for the time you made available to share this meeting with us.

Sincere thanks,

Fran Pierwola

Fran Pierwola
Conservation Director

FP/

WESTPORT CONNECTICUT
CONSERVATION COMMISSION
TOWN HALL 110 MYRTLE AVENUE
WESTPORT, CONNECTICUT 0688[illegible]

WATER [illegible]
UNIT
RECEIVED
JUN 2 [illegible]
ANSWERED ____
REFERRED ____
FILED ____

May 22, 1981

Bob Leach
State of Connecticut, DEP
Water Resources Unit
State Office Building
Hartford, CT 06511

RE: Shore Erosion Project
Compo Cove/Sherwood Island

Dear Bob:

It seems that articles in the News Papers in reference to the May 21, 1981 meeting of the Westport Conservation Commission raised public interest about the shore erosion project. Based on those articles that were published several concerned citizens have come forth with the following questions about the project:

1. Due to the fact that the west groin (recently improved on Sherwood Island) is blamed for several problems, including the cause of the severe erosion of Compo Cove; why doesn't the State propose to remove it?

2. Residents do not remember the cove ever being four (4) feet deeper than it is today. They say the cove always consisted of shallow flats. What proof or evidence do you have stating that the cove was four (4) feet deeper?

3. There are shellfish beds in the cove itself. What provisions will be made to protect these beds; both short-term during the work; and long-term? Will they re-establish to their present [illegible]ability?

4. Years ago, the residents stated that the outlet to the Mill Pond came straight out into the cove. Are there plans to return the channel outlet to this position?

In preparation for future hearings, I thought you might be interested in these questions.

Please be advised that it is my understanding that there i

much concern about the shore erosion project and there will be many such questions raised at the State Hearings on this matter.

Sincerely,

Fran Lierwola
Conservation Director

Fl es

CONNECTICUT STATE DEPARTMENT OF HEALTH SERVICES

MATERNAL AND CHILD HEALTH SECTION

SUBJECT: A-95 EIS#378
SHERWOOD ISLAND STATE PARK
SMALL BEACH EROSION CONTROL PROJECT
WESTPORT, CONN.

To: Andy Maben

From: Dennis Kerrigan, ~~Dep.~~ Commissioner

Date: 5/28/81

The commentary below is provided for applicant's information.

1. From Sherwood Point, Westport, CT, there are two large shellfish beds extending in a southerly direction, and twenty nine beds extending in a west-southwest direction Certification for twenty three of these designated privately owned shellfish beds have been issued by this Department to allow the harvesting and marketing of shellfish. The Department will be obliged to close these areas to harvesting if the dredging-replenishment operation results in levels of total coliform bacteria, mercury, or PCB's above the accepted national basis. The Department's sea water sample standard for areas open to shellfishing is a total coliform median level of 70/100 ml or below with 10 percent or fewer of those samples below 230/100 ml as determined by a 5-tube series MPN examination.

2. Maps, together with Department of Environmental Protection's Dredged Material Sediment Classification regarding all spoil and commercial fill to be deposited would aid in evaluating this project. The maps should designate the areas of dredging, spoil deposition, groin placement, and estimated quantity and extent of spoil dispension after deposition on the beach. These factors should be examined by someone familiar with the dynamics of sediment transport. Beach replenishment could result in a change in other beach areas, may smother shellfish on beds, or may only be temorary depending on design or groin placement. These aspects could be reviewed for comment by W. Frank Bolen, PhD., Associate Professor of Physical Oceanography, Marine Sciences Department, University of CT or by someone of similar expertise.

DK/gs

MCH 2 (8-77) 4M

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION I

J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

May 29, 1981

Colonel C. E. Edgar, III
Division Engineer
424 Trapelo Road
Waltham, MA 02254

Re: NEDPL-I - Beach Erosion Control at Sherwood Island State Park

Dear Colonel Edgar:

This letter concerns the Section 404(b) Factual Determination and Finding of Compliance for the proposed Beach Erosion Control Project, Sherwood Island State Park, Westport, Connecticut.

We have reviewed the evaluation and concur with the concerns pointed out by the National Marine Fisheries Service (NMFS) in their letter dated May 7, 1981. Specific comments are as follows:

1. There is no information to substantiate the statement that the sediments to be used for the beach erosion control project, do not contain contaminents in other than trace quantities, and will not cause adverse effects on aquatic organisms.

2. According to NMFS, there are known significant shellfish resources in the area which may be affected by the project. These include natural beds of hard clams (Mercenaria mercenaria) and oyster (Crassososhea verginica), which are not considered in the evaluation.

3. We question the inaccuracy of the statement that the proposed fill material will be (Pg. 2) compatible with existing sediments, since much of West Beach at the Park is a cobble-stone substrate. If in fact, the fill is not compatible with the existing beach, erosion may result, especially during storms.

4. Compliance with the restrictions a discharge under Sections 230.10(c) and (d) of the 404(b) Guidelines were not provided in this document. Section 230.10(c)(3), with respect to effects on Shellfish should be addressed. It is difficult to comment on the adequacy of action to minimize impacts as required in Section 230.10(d) since details were not fully described in the evaluation.

Therefore, we recommend that the proposed project be re-evaluated in light of the above concerns. If it is determined to proceed with the original proposal, then the 404(b) analysis should be revised to address these comments.

Thank you for the opportunity to comment on this public notice. Direct any questions regarding these comments to Kaye Cleghorn at 617/223-5061.

Sincerely yours,

Richard C. Boynton for

Allen J. Ikalainen, Chief
Special Permits Development Section

cc: USFWS
NMFS, Milford CT

STATE OF CONNECTICUT

OFFICE OF POLICY AND MANAGEMENT

June 1, 1981

Joseph L. Ignazio
Chief, Planning Division
Department of the Army
Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

Dear Sir:

Reference: NEDPL-I

The State Clearinghouse has offered various appropriate state agencies the opportunity to review and comment upon the proposed Sherwood Island State Park, Small Beach Erosion Control Project at Westport, Connecticut.

Comments have been received from the Department of Health Services and the State Historic Preservation Officer. We would like to call your particular attention to the comments of Deputy Commisszoner Dennis Kerrigan of the Department of Health Services. A copy of the comments made by each of these state agencies is enclosed.

Sincerely,

Aden H. Maben

Aden H. Maben
State Clearinghouse Coordinator

AHM/dch

Mr. Bruha

NEDPL-I Presence of Shellfish Resources off West Beach, Sherwood, CT

Chief, Planning Division	Mr. Dupee Mr. Bruha	9 June 1981 Mr. Dupee/mm/233 Mr. Bruha/mm/534

1. We have received comments from Environmental Protection Agency, Fish and Wildlife Service, and National Marine Fisheries Service on our 404 Evaluation Report expressing their concern for shellfish resources off the West Beach. These included oysters, hard and soft shell clams.

2. According to information available to us at the time the report was prepared no formal shellfish surveys have been made in the area. On 1 June 1981, Mr. Bruha and Mr. Dupee conferred with Mr. Charles McElwee who is the Westport, Connecticut Shellfish Officer. He advised us that the West Beach contains a negligible amount of clams and is not considered a viable shellfish resource to the town. He further stated that the few clams present are under sized and are not utilized. Mr. McElwee also stated that we could quote his remarks in our report.

3. The oyster leases offshore would not be affected by our efforts according to the officials present at the meeting at the site on 29 April 1981. The meeting included State and Federal officials as well as the owner of an oyster lease.

DUPEE BRUHA

cc: Mr. Dupee
Mr. Bruha ✓
Planning Div Files

15 June 1981

The following comments apply to the letters received from the United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 7 May 1981; the United States Department of the Interior, Fish and Wildlife Service, Ecological Service, 12 May 1981; and The United States Environmental Protection Agency Regional, 29 May 1981.

Since receiving the above mentioned letters and comments, this office has made an attempt to determine how significant the shellfish resource is at Sherwood Island State Park and the adjacent shoreline. The National Marine Fisheries Service and the U.S. Fish and Wildlife Service were both contacted to discuss the findings of their survey. With this information we could attempt to provide a mitigation plan to offset the impact of our proposed plan. Unfortunately, no detailed survey had been undertaken by either agencies prior to the initiation of their letters. We took the liberty of contacting Mr. Charles McElwee, the Westport, Connecticut Shellfish Officer, who informed us that there is no significant shellfish activity along West Beach. We also contacted the Sherwood Island State Park Superintendent to discuss the clamming activity on West Beach. He had no knowledge of this area as a viable resource, but informed us that he had, at times, seen an occasional clam digger.

This is not considered to be a resource that could be recognized over the years. Due to the dynamics of the area, material in the intertidal zone is moving. During the winter months the rocky shore is exposed, some years more than others. During the summer beach building time, one to three feet of sand can cover these rocks. We are told that clams cannot survive if they are covered by more than a few inches of sandfill for more than forty eight hours.

We are aware of the commercial oyster beds located offshore. Our proposed project, with the low profile groin structure, will have little or no impact in this area. Shoreline and offshore change maps clearly indicate that the offshore configuration has changed very little over the years. With the addition of the low profile groin structure, alongshore movement of material will be reduce considerably. We forsee no major impact on the offshore configuration or in Compo Cove.

The proposed beach fill material will be as good or better in quality than that which is presently found on the beach. The material on West Beach in the summer consists of medium to fine sand, covering many cobbles and rocks in the intertidal zone (see inclosed report photos). Detailed specifications for the proposed material, such as grain size, sorting characteristics, percent passing, and other data will be based on criteria established in the "Shore Protection Manual" prepared by the Department of the Army Corps of Engineers, U.S. Army Coastal Engineering Research Center.

The recommended plan, which includes a low profile groin structure will extend the mean high water shoreline along the eastern 1000 feet of West Beach approximately 50 feet seaward of the 1957 mean high waterline. Along the remaining 800 feet, the mean high waterline will be extended seaward about 25 feet from the 1957 mean high waterline. It is impractical to place sandfill in the tree and grassy picnic area located behind the beach, because on peak days the entire park is overcrowded. To reduce this area would not be a viable alternative.

Our studies indicate that the proposed groin will interupt the waves that are now causing alongshore movement in the nearshore area. However, material will continue to move westward in the offshore area naturally. Also, wind blown sand will move over the groin and continue to move along the beach.

The improvement for West Beach has been designed and analyzed based on our knowledge of the most recent state of the art criteria and for the conditions as they exist at Sherwood Island and in Long Island Sound.

Upon completion of the project, we are recommending that the Corps establish a monitoring program. This program wil consist of periodic surveys to determine the effectiveness of the groin structure with respect to sand movement. Included in the program will be West Beach and Compo Cove.

STATE OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

COASTAL AREA MANAGEMENT PROGRAM

June 17, 1981

Ms. Fran Pierwola, Conservation Director
Town Hall
110 Myrtle Avenue
Westport, Ct. 06880

RE: Letter of 5/22/81

Dear Fran:

Thank you for your letter of May 22, 1981 which called to my attention four pertinent questions regarding the proposed Sherwood Island/Compo Cove/ Old Mill Beach erosion control projects. The questions apparently came to light as a result of my meeting with the conservation commission which you were so helpful in arranging.

Each of the questions is germane to the project and they have all been considered during development of its design. Consequently, their answers are contained in the initial work which was done by Flaherty-Giavara Associates or will be presented in the forthcoming Environmental Impact Evaluation (EIE) which is being prepared by my Department. Since, as I understand your letter, no immediate or seperate response is desired we will address these questions through the EIE.

If this response is not satisfactory to you or members of your commission please let me know as soon as possible.

Thank you again for your kind assistance.

Very truly yours,

Robert H. Leach
Principal Environmental Analyst

RHL/11

cc: Tom Bruha
U.S.A.C. of E.

Phone (203) 566-7404
71 Capitol Avenue • Hartford, Connecticut 06115

STATE OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

COASTAL AREA MANAGEMENT PROGRAM

June 17, 1981

Mr. Thomas Bruha
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Ma. 02254

RE: Sherwood Island, Compo Cove and Old Mill Beaches, Erosion Control.

Dear Tom:

Enclosed are copies of the correspondence I received from Fran Pieriwola, Westports' Conservation Director, as a result of my meeting with her commission to discuss our erosion control plans for both the State Park's West Beach (Corps Sponsored) and Compo Cove and Old Mill Beaches (State Sponsored). The meeting was very congenial and the commission seemed receptive to the proposals although they made no commitment to any plan of action. I discussed both projects in detail and showed them all the preliminary plans.

My response to Fran's letter will be forthcoming and I will see that you get a copy.

Sorry for the delay in response.

Very truly yours,

Bob

Robert H. Leach
Principal Environmental Analyst

Appendix 3
3-30

RHL/11
Enclosure

Phone: (203) 566-7404
71 Capitol Avenue • Hartford, Connecticut 06115

US Army Corps of Engineers
New England Division

News Release

81-373	Sue Douglas or Tom Bruha
Release No.	Contact:
Upon Receipt	617-894-2400, X237 or 554
For Release:	Phone:

424 Trapelo Road, Waltham, Massachusetts 02254

ENGINEERS PLAN WALK/TALK PROGRAM ON SHERWOOD ISLAND'S WEST BEACH

WALTHAM, Mass. -- All who are interested in the possible restoration of Sherwood Island State Park's West and Compo beaches are invited to inspect the area and attend a public workshop and discussion on June 30, 1981. The U.S. Army Corps of Engineers has proposed a $943,100 plan to place sandfill on the beach and to construct one low profile groin to compartmentalize the sand. The State of Connecticut has proposed placement of sandfill, channel excavation and the construction of four structures for Compo Beach.

Colonel C. E. Edgar, III, head of the Corps' New England Division, extended a public invitation on behalf of the Corps and the State to meet at the Sherwood Island State Park Beach pavilion at 6:00 P.M. to walk the beach and obtain first hand information on the proposed improvements and then to join in a workshop discussion at the pavilion following the walk. Visual aids and handouts will be available.

"Public comments and views received at the workshop will greatly assist us in reaching a decision on whether the work should be accomplished," Colonel Edgar said. Should federal funds be available, the work would be accomplished by a private firm under contract with the Engineers.

-30-

MAP, FACT SHEETS ATTACHED

18 June 1981

US Army Corps of Engineers
New England Division

Project Information

WEST BEACH, SHERWOOD ISLAND STATE PARK
BEACH EROSION CONTROL STUDY

424 Trapelo Road, Waltham, Massachusetts 02254

TYPE OF PROJECT:	Beach Erosion Control Study
LOCATION:	Westport, Connecticut, on the Long Island Sound, approximately 10 miles west of Bridgeport, Connecticut, and 40 miles east of New York City.
AUTHORITY:	Section 103 of the River and Harbor Act of 1962, as amended for small beach erosion control projects.
PURPOSE:	To provide shore protection, encourage healthful beach bathing, and prevent future damages due to the natural elements.
PROJECT:	The plan of improvement for West Beach consists of providing a 275-foot wide dry beach above the mean high water line by the direct placement of suitable sandfill along 1,800 feet of shoreline, lowering the landward end of the existing Federal groin structure, and the construction of one low-profile groin structure located between Sherwood Point and the existing Federal groin.
DATE STARTED:	Reconnaissance Report approved June 1980.
DATE COMPLETED:	Detailed Project Report scheduled for submittal for approval in September 1981.
COST:	Total first cost $936,000.
COST-SHARING:	The State of Connecticut will bear 30 percent of the total first cost and annual charges. The Federal Government will bear 70 percent of these costs.
CURRENT STATUS:	The Detailed Project Report is now in the final stage of completion and is scheduled to be submitted to the Office of the Chief of Engineers for approval in September 1981. The construction should begin in early spring of 1982.
CONTACT:	Thomas Bruha, Project Manager, 617-894-2400, extension 554.

STATE OF CONNECTICUT
Department of Environmental Protection
State Office Building
Hartford, Connecticut 06115

COMPO COVE BEACH

FACT SHEET

TYPE OF PROJECT:	Beach Erosion Control Study
LOCATION:	Adjacent to Sherwood Island State Park, West Beach, Westport, Connecticut
PURPOSE:	To provide shore protection and prevent future damages due to the natural elements.
PROJECT:	The plan of improvement for Compo Cove Beach consists of beach widening by the direct placement of suitable sandfill, the construction of two low-profile groins on the beach, and one structure on either side of the entrance to the inlet. Sandfill will also be placed on Old Mill Beach. *No work is scheduled to be done in* Sherwood Pond.
CONTACT:	Robert Leach, Project Manager, 203,566-7404.

NEDPL-C

TRIP REPORT
SUBJECT: Sherwood Island State Park, Westport, Connecticut

1. Date: 30 June 1981

2. Location: Sherwood Island State Park, Westport, CT

3. Subject: Walk/talk meeting with Federal, State, local officials, and concerned citizens.

4. Attendees: See attached attendance list

5. Summary:

a. The meeting began at the pavilion where I introduced myself and distributed copies of the information sheets and a plate of the selected plan. With the use of various plates and maps, I briefly explained the study area and the proposed plan of improvement, which includes providing a 275-foot wide dry beach above the mean high waterline by the direct placement of suitable sandfill along 1,800 feet of shoreline, lowering the landward end of the existing Federal groin structure, and the construction of one low-profile groin structure located approximately 900 feet west of Sherwood Point.

b. A question arose as to why the existing Federal groin is in the process of being raised if the plan of improvement is to lower it. I stated that I was unaware of this work being done but that I would check into it. No one at the meeting knew who was responsible for the dumping of rock on the existing Federal groin.

c. Mr. Bob Leach of the Connecticut Department of Environmental Protection then gave a presentation of the State project at Compo Cove Beach which includes Compo Mill Beach and Old Mill Beach. This project provides 20,000 cubic yards of snadfill along 800 feet of beach, two low-profile groins, and two terminal groins, one on either side of Sherwood Mill Pond inlet. A discussion then began of borrow areas and source of sand.

d. I explained that we had contacted four possible suppliers for the West Beach sandfill and that all stated that they have enough sand to supply us for this project.

e. We then proceeded to walk along the beach, starting at Sherwood Point. I explained the problems the beach was experiencing and restated the proposed plan to correct these problems. We continued walking along the beach and I pointed out where we proposed to build the low-profile groin. We proceeded to the existing Federal groin and we observed that boulders had indeed been dumped at the groin. I explained that we proposed to lower this groin approximately 1.5 feet to allow wind blown sand to move freely along the beach to the west and hopefully provide some nourishment to the adjacent State land and Compo Cove Beach.

NEDPL-C SUBJECT: Sherwood Island State Park, Westport, CT

f. A discussion began of the clam and oyster habitat located on West Beach and if the proposed snadfill would destroy the beds. Mr. Charles McElwee, Shellfish Warden, stated that there are no clams or oysters in the area of the proposed project. The meeting was then ended.

6. Import/Impact on NED: Public comments and views were received and assisted us in reaching a decision to proceed with the project.

THOMAS C. BRUHA

30 June 1981

WALK/TALK MEETING
SHERWOOD ISLAND STATE PARK
WESTPORT, CT

ATTENDANCE

NAME	ORGANIZATION
George R. Butzko	Westport
Fred C. Benson	U.S. Fish and Wildlife Service
Charles McElwee	Westport - Shellfish Warden
Dominick A. Calise	Westport
Win Robinson	U.S. Fish and Wildlife Service
Mr. & Mrs. Allen Raymond	Compo Cove
John C. Clark	Weston
Tom Lesley	Compo Cove
Edward Harrison	Compo Cove
Larry Johnston	Westport
John Cappiello	WNLK Radio News, Norwalk
Jill McDonald	WMMM Radio News
D. R. Hall	Westport News
Edward Nielsen	Geneovese & Assoc., Consulting Engineers, Hamden, CT
Marianne Engelman	Senator Dodd's Office
Jeff Perlman	Bridgeport Post-Telegram
Thomas C. Bruha	Corps of Engineers, Coastal Dev. Br.
Catherine LeBlanc	Corps of Engineers, Coastal Dev. Br.
James Doucakis	Corps of Engineers, Coastal Dev. Br.
Maureen Cummings	Corps of Engineers, Coastal Dev. Br.
Dave Dupee	Corps of Engineers, Impact Analysis Br.
LT Wayne Johnson	Corps of Engineers

COMPO COVE PARK ASSOCIATION, INC.
Allen A. Raymond, President
70 Compo Cove
Westport, Ct. 06880

July 1, 1981

Colonel C.E. Edgar, III
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Edgar:

As President of the Compo Cove Association, I've watched with interest the skill and tact -- and thoroughness -- with which the restoration of Sherwood Island beaches has been handled by your organization.

Last evening I attended a meeting at the Park in which the project was explained. This was an expansion of a similar meeting held with our own Association back in late May. Hopefully it will move ahead rapidly, and if you need any support from our organization, please know that we will do anything we can.

It was mentioned during the meeting that periodic (annual?) aerial surveys of the area would be made, once the work has been completed. These surveys would help determine what happens from year to year.

This seems like a splendid idea, and I only hope our Association will be informed of the results. This will help guide us -- and the Town of Westport -- in annual maintenance. Such maintenance can perhaps eliminate the need for another major project in future years.

Again -- thanks from all of us for what has been planned. I hope you will pass on to others in your organization our appreciation.

Sincerely,

Allen A. Raymond
President

AAR/rmb

P.S. A special thanks to Mr. Brusha, please!

Planning Div.

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

July 30, 1981

WATER QUALITY CERTIFICATION

C.E. Edgar, III
Colonel, Corps of Engineers
Division Engineer
New England Division
Army Corps of Engineers
424 Tropelo Road
Waltham, Massachusetts 02154

Dear Colonel Edgar:

The Department of Environmental Protection has reviewed your application for the restoration of the West Beach of Sherwood Island State Park in Westport, Connecticut as outlined in the U.S. Army Corps of Engineers Public Notice NEDPL-D dated 20 April 1981. The project will involve placing 125,000 cubic yards of sand fill on an 1800 foot long section of cobble beach to provide a sand beach 325 feet wide above mean high water. A portion of the fill material will come from Compo Beach cove which will then be covered with an additional 6 ft. of sand from an upland borrow area. The landward end of the existing Federal groin, located at the western limit of the proposed improvement area, will be lowered to allow wind-blown sand to move along the beach. An additional low profile groin will be constructed between the west limit of study and Sherwood Point. The project will eliminate the habitat provided by the cobblestone substrate and possibly stress the natural beds of hardclams and commercial oyster beds. Since the primary purpose of Sherwood Island State Park is to provide "beach" recreation for residents of Connecticut and New York City and since a similar type of enhancement occurred in the mid 1950's during the construction of the park a precedent has been set for the use of the area to favor this form of recreation.

Therefore, based on this precedent and pursuant to Section 401(a)(1) of the Federal Water Pollution Control Act, as amended, the Department of Environmental Protection hereby certifies that the proposed project will not permanently violate Connecticut's Water Quality Standards provided that no dredging or other construction activities that would elevate turbidity levels occur between June 1 to September 30 of any year. With regard to its water quality related aspects, this action is further found to be consistent with the applicable policies of the Connecticut Coastal Management Act (Section 22a-92 of the Connecticut General Statutes as amended by Section 2 of P.A. 79-535).

This is not the permit or authorization required under Section 25-7d; 25-11; 22a-32; or 22a-36 to 45, inclusive, of the Connecticut General Statutes as amended. These sections pertain to encroachments, dredging, or work waterward of mean high water in coastal, tidal or navigable waters, work in designated tidal wetlands, encroachments or obstructions channelward of established stream channel encroachment lines and work in inland wetlands and watercourses.

Sincerely yours,

Stanley J. Pac

Stanley J. Pac
Commissioner

Appendix 3
3-38

SJP:KH:mg

cc: Army Corps of Engineers
Water Resources
CAM
NMFS

10 AUG 1981

NEDPL-C

Mr. Stanley J. Pac
Commissioner, Dept. of
Environmental Protection
State Office Building
Hartford, CT 06115

Dear Mr. Pac:

It is requested that your department certify that Sherwood Island State Park, West Beach Erosion Control Project is consistent with the State of Connecticut Coastal Zone Area Management Program.

We have reviewed your planning report number 30 titled "Coastal Policies and Use Guide Lines" for consistency. It has been determined that the project is consistent with the overall Coastal Zone Area Management Program. We have further determined that the project is well within the limits of placing clean fill material in coastal waters, and we are requesting a water quality certificate for West Beach. As you are aware, this project is a joint effort with the State of Connecticut to replenish and replace the beach in this heavily-used beach area. The consistency certification worksheet has been completed by the State Department of Environmental Protection and is included in the State's Environmental Evaluation. The evaluation addressed both the Federal and the State project and will be forwarded to the Corps prior to submission of our report to the Office of the Chief of Engineers for approval.

In order for us to maintain our scheduled time table, I would appreciate a response from your office as soon as possible to enable us to forward a final Detailed Project Report to the Office of the Chief of Engineers for approval in September 1981.

Sincerely,

C.E. EDGAR, III
Colonel, Corps of Engineers
Commander and Division Engineer

State of Connecticut

Department of Environmental Protection

State Office Building Hartford, Connecticut 06115

Stanley J. Pac
Commissioner

August 25, 1981

Colonel C.E. Edgar, III
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Mass. 02254

ATTN: NEDPL-C

Dear Colonel Edgar,

I am in receipt of your letter dated 10 August 1981 in which you request certification of the consistency of the Sherwood Island State Park West Beach Erosion Control Project with Connecticut's Coastal Area Management Program. This letter shall constitute such certification.

Upon review of the August 1981 Draft Section 103 Small Beach Erosion Control Report for Sherwood Island State Park, West Beach, my staff reaffirmed the consistency of the proposed project with the State's Coastal Area Management Program. As stated in your letter, the State's Environmental Impact Evaluation will include the Coastal Management Consistency worksheet prepared by my staff. I would recommend that the pertinent sections of that worksheet be appended to the Final Section 103 Report.

Also requested in your letter was a Water Quality Certification. I trust you have received such certification dated July 30, 1981.

Please keep me informed of the progress of this project. If we can be of further assistance, please call Jane Kreisman at 566-7404. Thank you.

Sincerely,

For Stanley J. Pac

SJP/JK/el

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. Box 1518
Concord, New Hampshire 03301

SEP 10 1981

Colonel William E. Hodgson
Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Colonel Hodgson:

This is our Fish and Wildlife Coordination Act Report on your study of beach erosion control measures for Sherwood Island State Park, Westport, Connecticut, including our comments on your Draft Detailed Report dated August 1981. Our report was prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and it supplements our previous reports and letters concerning this project.

We have no objections to your selection of Plan 3 consisting of sand fill, modification of the west groin, and construction of a new groin which will increase opportunities for shore fishermen. This groin also will replace some of the beach cobble habitat that will be covered by sand fill. There will be some loss of benthic habitat caused by the sand fill. The cobble habitat will not be completely replaced and therefore there will be a loss of the species associated with this productive habitat. The magnitude of the habitat loss cannot be predicted because of your plans to avoid unnecessary loss during construction and the predicted future natural changes in the shoreline clearly explained in your draft.

We feel that the anticipated adverse impacts on fish and wildlife habitat should be explained more clearly in your report. For example, the section "Mitigation Requirements" on page 12 explains that extra effort will be made during construction to avoid adverse impacts upon the cobble habitat but states that it is not an "active shellfish area". During a site visit with members of your staff, we saw numbers of soft-shell clams in this area that had been dug by beach users. It might be more appropriate to say that soft-shell clams, mussels, snails, and other marine life inhabits this cobble area and the number of species and abundance of individuals is greater than on the sand beach.

A similar discrepancy is found on page 4, last paragraph where the clams are described as "not a viable resource". This should be revised to explain that the clams are not significant either in numbers, quality of habitat, or human use, but that some do exist and could be used by the public with appropriate license.

cc [illegible]

We do not agree with use of "could" in line 8 of paragraph d, page 33. The listed species do exist there now.

The statement that the loss of productive habitat (conclusions, paragraph c, page 42), will be offset by groin constfuction should be qualified. The meaning of offset is not clear in this context. It might be clearer to say that construction and maintenance of the groin will partly offset loss of productive cobble and rocky areas.

The Section 404(b) documents are the same as previously reviewed, so our letter of comment dated May 12, 1981, still applies.

We will review and comment on your final draft report before completing our coordination with you on this project.

Sincerely yours,

Gordon E. Beckett
Supervisor

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

September 15, 1981

Colonel C.E. Edgar, III
Division Engineer
New England Division, Corps of Engineers
U.S. Department of the Army
424 Trapelo Road
Waltham, MA 02254

Re: NEDPL-C Beach Erosion Control at Sherwood Island State Park

Dear Colonel Edgar:

We have reviewed the Draft Environmental Assessment concerning the feasibility of providing beach improvements for Sherwood Island State Park in Westport, Connecticut.

In our May 29, 1981 letter after reviewing the Section 404(b) Factual Determination and Finding of Compliance for the project, we stated some comments concerning issues that were of concern to us. Upon review of this Environmental Assessment, our major concerns were addressed. Therefore, we have no objection to this proposed project.

Thank you for the opportunity to comment on this Draft Environmental Assessment. Questions regarding these comments should be directed to Kaye Cleghorn, at 617/223-5061.

Sincerely yours,

Allen J. Ikalainen

Allen J. Ikalainen
Chief, Special Permits Section

cc: NMFS, Gloucester, MA

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

New England Area Office
P. O. Box 1518
Concord, New Hampshire 03301

Colonel William D. Hodgson
Deputy Division Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

SEP 14 1981

Dear Colonel Hodgson:

We are sending you endangered species information to assist you in planning for the Sherwood Island State Park, Westport, Connecticut.

Our review shows that except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further consultation is required with us under Section 7 of the Endangered Species Act. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our concerns under the Fish and Wildlife Coordination Act.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Acting Area Manager

APPENDIX 3

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ENGINEERING INVESTIGATION, DESIGN, AND COST ESTIMATES

This appendix will address in detail the design criteria used in the design of the improvements. The criteria will apply to the design of those plans that have sufficient public use benefits to economically justify construction of the project. Tables showing cost estimates of the considered plans of improvements including first cost, annual charges, and periodic nourishment are shown along with the detailed cost estimate of the selected plan of improvement.

TIDAL HYDROLOGY

GENERAL

This appendix presents climatic and tidal hydrologic information necessary both to evaluate erosion processes at Sherwood Island State Park, West Beach and to design proper corrective measures. In this appendix the factors causing water level variations are examined.

Wind generated waves are the principal agent of coastal erosion. Nearshore currents generated by waves, winds, astronomical tides, or riverine flow also play an essential role. The precise location of most active erosion is determined to a significant extent by the water level as averaged over many tide cycles and wave periods. Substantial variations in water level can be produced by astronomical tides and by storm surges caused by the combination of high onshore winds and low atomspheric pressure.

ASTRONOMICAL TIDES

THE REASON FOR TIDES

Tides result mainly from the sea's response to the moon's gravitational attraction. The sun, being much farther away from the earth, has a much lesser tide producing effect. In the study area, two high and two low tides occur during each lunar day (semidiurnal tides). The lunar day is the time required for one rotation of the earth relative to the moon (approximately 24 hours 50 minutes). The difference in height between consecutive high and low waters (the tide range) is affected by three main factors:

(1) The tide range varies with the alignment of earth, moon, and sun as observed by the phases of the moon. A complete cycle through maximum range at full or new moons (spring tide) and minimum range at quarter moons (neap tide) takes about 14 3/4 days.

(2) The varying distance between the earth and moon during its 27 1/3 day elliptical orbit about the earth causes an increased range when closest (perigean tide) and a decreased range (apogean tide) when farthest away.

(3) The declination of the moon and to a lesser extent the declination of the sun, from the equator, tends to produce inequalities in the two low and two high waters each lunar day (diurnal inequality). As the moon crosses the equator in its orbit about the earth, this inequality is at a minimum (equatorial tides) and as its declination, either north or south, becomes greatest so does the diurnal inequality (tropic tides).

Maximum tide ranges occur when two or more of these cycles are in phase. A complete sequence of tide ranges is approximately repeated at intervals of 19 years, which is known as a tidal epoch. At Sherwood Island State Park Beaches, the mean range of tide and the mean spring range of tide are estimated to be 7.0 feet and 8.0 feet, respectively (see Figure 4-1 and Tidal Datum Planes paragraph). This estimate is based upon currently available short term data from nearby National Ocean Survey tidal benchmark locations. The variability of astronomical tide ranges is a significant factor in tidal flooding potential.

TIDAL DATUM PLANES

Because of the continual variation in water level due to the tides, several reference planes, called tidal datums, have been defined to serve as a reference zero for measuring elevations of both land and water. The most fundamental of these is mean sea level, abbreviated as MSL. Mean sea level is defined as the arithmetic mean of hourly water elevations observed over a specific 19-year metonic cycle (the National Tidal Datum Epoch). The epoch currently in use for mean sea level determination in the United States is 1941-59. Sea level is rising with respect to the land along most of the U.S. coast. In the study area, based on known trends at neighboring National Ocean Survey primary tide gage sites, the rise has been observed to be slightly less than 0.1 foot per decade. Sea level determination is generally revised at intervals of about 25 years to account for the changing sea level phenomenon.

Mean sea level is defined only for explicit locations where suitable tide records are available. A reference level that can be used as a zero-base in elevation measurements, even where no tide records are available, is needed for mapping and many other applications. This reference is provided by the National Geodetic Vertical Datum of 1929 (NGVD), which was established by overland geodetic surveys with the intention of having the Geodetic Vertical Datum coincide with local mean sea level at 25 U.S. and

Canadian tide stations. Geodetic surveys from the coast have been used to carry this datum to a network of benchmarks covering the United States. Because sea levels have risen relative to the land, the NGVD is lower now than the MSL most everywhere in the United States.

A third tidal datum, widely used by coastal engineers along the Atlantic coast, is mean low water (MLW). Mean low water is defined as the arithmetic mean of low water water heights observed over a specific 19-year metonic cycle (the National Tidal Datum Epoch). Like mean sea level, mean low water is properly defined only for specific tide gage locations. Mean low water is a useful datum for hydrographic surveys, particularly in support of navigation where minimum water depth is the critical parameter. At Sherwood Island State Park Beach, MLW is estimated to be 2.9 feet below NGVD (see Figure 4-1).

The mean of the high water heights is defined similarly to MLW and is called mean high water (MHW). Since MLW and MHW are more easily computed than MSL, an approximation for MSL called mean tide level (MTL) is frequently utilized. MTL is a tidal datum midway between MHW and MLW. At the study site, MTL is about 0.6 foot above NGVD (see Figure 4-1).

When only the spring tides are considered, the mean of the spring low water heights (MLWS) and the mean of the spring high water heights (MHWS) can be determined. MLWS is about 0.5 foot below MLW (see Figure 4-1).

METEOROLOGICAL FACTORS

STORM TYPES

Two distinct types of storms, known as extratropical and tropical cyclones, influence coastal processes in New England. These storms can produce above normal water levels and must be recognized in studying New England coastal problems.

Extratropical Cyclones - These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold dry continental air mass and a warm moist marine air mass just off the coast of Georgia or the Carolinas and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1,000 to 1,500 miles from the storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. Since the storm center generally passes parallel and to the southeast of the New England coastline, highest onshore wind speeds are generally from the northeast. For this reason these storms are often called "nor'easters". As the storm passes, local wind directions may vary from southeast to slightly west of

north. Coastlines exposed to these winds can experience high waves and extreme storm surge. The prime season for nor'easters in New England is November through April.

Tropical Cyclones - These form in a warm moist air mass over a tropical ocean. The air mass is nearly uniform in all directions from the storm center. The energy for the storm is provided by the latent heat of condensation. When the maximum wind speed in a tropical cyclone exceeds 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated based upon the distance from the storm center and the forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally have crossed Long Island Sound and proceeded landward in a generally northerly direction. However, hurricane tracts can be erratic. The storms lose much of their strength after landfall. For this reason the southern coast of New England experiences the greatest surge and wave action from the strong southerly to easterly flowing hurricane winds. However, on very rare occasions, reaches of coastline in northern New England can experience some storm surge and wave action from the weakened storm. The hurricane season in New England generally extends from August through October.

GENERATION OF WAVES BY WIND

When a steady wind starts to blow over a calm body of water, waves are developed. The wave height and period increases with the wind speed, the duration of the wind and the distance (fetch) over which the wind blows. The exact physics of the process are not yet fully understood, but the foregoing statements are universally accepted. The wave height and period may ultimately reach a maximum with duration or fetch of the wind. The maintenance of wave gages near the coast during storms is difficult, and it is nearly always necessary to use estimates of wave conditions (wave "hindcasts") based on available meteorological data to obtain a substantial part of the wave estimates needed for engineering analysis of processes and projects in the coastal zone.

WINDS

An estimate of wind speed is one of the essential ingredients in any wave hindcasting effort. The most accurate estimate of winds at sea, which can generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. However, actual recorded wind speed and direction data at land based coastal meteorological stations can serve as a useful guide when more locally generated waves and currents are of interest. The disadvantage of using land based wind records is that they may not be totally indicative of wind velocities at the sea-air interface where the waves are generated. However, often they are the only available source of information.

The National Weather Service has monitored wind speed and direction at Bridgeport, Connecticut since 1947; this being the closest location to the project for which systematically recorded wind data is available. Utilizing wind data recorded at Bridgeport in three hour intervals, the percent occurrence of wind direction for various wind speed ranges has been computed. Since only onshore winds at Sherwood Island State Park beach are of interest, the wind directions utilized in the study have been limited to those between east (E) and west-southwest (WSW). This analysis, the results of which are shown in Table 4-1(a), indicates that the principal onshore wind direction for the slower and intermediate speed winds (less than or equal to 25 mps) is from the SW to WSW. Higher wind speeds (over 25 mps) are generally from the east. Overall, SW is the principal onshore wind direction. The maximum speed was 57.5 mph from the E and WSW. Overall average speed is 11.5 mph. The percent occurrence of wind speed and direction is shown in Figure 4-2. Table 4-1(b) shows the resultant wind direction and percentage of observations for various wind speed ranges. The resultant wind direction is a vector quantity computed using the product of wind speed and direction. It is an indicator of net air movement past a given location. Overall, the resultant wind direction is from the SSW at the average resultant speed of 6.9 mph. The greatest percentage of wind speeds is shown to be in the 10 to 15 mph range.

Waves generated during coastal storms are particularly potent as an erosive force. Therefore, it is useful to examine wind conditions occurring during past storms when estimating the severity of wave conditions. Table 4-2 presents National Weather Service, tri-hourly wind observations recorded at Bridgeport during days of storm induced tidal flooding. It can be seen that the strongest winds recorded on these dates generally occurred between northeast and east. The highest speed listed, 57.5 mph from the east was recorded on 25 November 1950. It should be noted that these values are based on tri-hourly observations, therefore, the true daily maximum may be greater.

EFFECTS OF STORMS ON WATER LEVELS

Three distinct processes may produce an increased water level near the coast during storms.

THE INVERTED BAROMETER EFFECT

In the deep sea, a reduction in atmospheric pressure is accompanied by a rise in the sea surface which will lead toward a constant pressure level at some distance below the water surface. For equilibrium to be achieved the water would have to rise about 13.25 inches for an atmospheric pressure drop of 1 inch of mercury, the approximation of a 1-foot rise in water level for a 1-inch fall in pressure is often used. Nearshore boundary conditions at the bottom or sides may alter the response of the sea to pressure changes so that the actual rise is

generally less than that indicated above, but it can be greater. This tendency for the water level to rise under low atmospheric pressure is often called the "inverted barometer effect."

WIND SET-UP

Friction between the wind and the water surface generates a current, which is initially parallel with the wind, but which, because of the rotation of the earth, rotates toward the right with increasing time and increasing depth, so that the water transport due to a steady wind on very deep water is about 90° to the right of the wind. In shallow water, far from the shore, the direction of the wind generated current differs little from the direction of the wind. Near the shore the current is constrained to flow parallel to the shore, but because of the earth's rotation, the mean free surface slopes upward to the right of the wind. Thus both the componenet of the wind that is directed onshore and the component that is parallel to the shore, with the shore to the right, tends to produce above normal water level. The direct effect, wind set-up, is inversely proportional to the water depth. Thus the effect of a given wind velocity is greater at low tide than at high tide and is limited to shallow waters near the shore. The wind effect is approximately proportional to the square of the wind speed.

WAVE SET-UP

The mean water velocity due to periodic waves vanishes beneath the wave trough. Between the wave trough and the wave crest, however, there is always net flow in the direction of wave propagation. The magnitude of this flow is proportional to the square of the wave height, which in turn is a function of the fetch. Thus the mean current due to the waves increases more or less continuously from deep water to the breaker zone, thus producing a downward slope of the mean water surface from the region in which the bottom begins to affect the waves to the breaker zone. The wave amplitude must vanish in the region between the breakers and the water line, producing an upward slope of the water surface called the wave set-up. The wave set-up is often steeper than the wind set-up, but it is restricted to a much more narrow region near the shore.

The wave set-up is usually correlated with the wind set-up because high winds and high waves are often correlated. However, the process of wave generation extends much further seaward than the effective wind set-up. Waves can travel as swells far from their region of generation. Thus wave set-up can occur in the absence of wind or even with an adverse wind.

The combined effects of winds, atmospheric pressure and wave set-up on the water level are often called the storm surge. The contribution due to wave set-up is often neglected.

COMBINED EFFECTS OF ASTRONOMICAL TIDES AND STORM SURGE ON WATER LEVEL

GENERAL

The combined effect of astronomical tides and storm surge is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, the time of occurrence of the storm surge greatly affects the magnitude of the resulting tidal flood level. A storm surge of 3 feet occurring at low astronomic tide would not produce as high a water level as would be produced if it occurred at high tide. It is important to note that the storm surge itself varies with time thus introducing another variable into the make-up of the total flood tide.

SUMMARY OF EXTREME HIGH TIDES AT BRIDGEPORT

The National Ocean Survey (NOS) has systematically recorded actual tide heights at Bridgeport, Connecticut since 1968. The record prior to that time was developed utilizing staff gage measurements taken by the Bridgeport Harbormaster, recording tide gage readings taken at Bridgeport by the Corps of Engineers, high water marks observed at Bridgeport, and records of the NOS recording tide gage at New London which is stage-related to Bridgeport. Maximum observed stillwater tide heights (measurements taken in protected areas using a device in which waves are dampened out) recorded up to 1975 are shown in Table 4-3. Also explained are the tide heights with an adjustment applied to account for the effect of rising sea level (see Tidal Datum Paragraph). The three highest observed tide levels listed were all caused by hurricanes, while the lesser tide levels were caused by both tropical and extratropical coastal storms. This clearly shows the extratropical storm as the prevalent type of storm affecting the study area. However, the most severe flooding is caused by hurricanes.

TIDAL FLOOD FREQUENCY

Adjusted annual maximum stillwater tide heights have been utilized to develop tide stage-frequency relationships at Bridgeport and other locations in Long Island Sound where suitable tide data is available. These Pearson Type III distribution functions for expected probability have been used to develop flood profiles for the Sound (see Tidal Flood Profiles paragraph). By utilizing these profiles, the tidal flood frequency relationship for Sherwood Island has been estimated (see Figure 4-3).

TIDAL FLOOD PROFILES

Profiles of major tidal flooding events have been developed along the New England coast. NOS tide gage records and high water marks gathered between gage locations after major storms have been utilized in the

development of these profiles. Additionally, profiles of storm tides of selected frequencies have been developed utilizing frequency distributions at tide gages and high water mark information. Location maps and profiles for the reach of New England coast bounding Westport are shown on Plates 4-3 through 4-6.

CONSIDERED PLANS

Every effort was made to involve the public on all levels, including The National Marine Fisheries Service; The Fish and Wildlife Service; The State of Connecticut, Department of Parks and Recreation; The Office of State Environmental Protection, The Westport, Connecticut, Selectmen; other State departments; and concerned citizens of Compo Cove Beach. This was accomplished through personal visits and regular meetings throughout the course of the study. Of the four considered plans, three consisted of beach widening with three different level beach berm widths and one a shore management plan. These plans are discussed in detail in Appendix 2.

DESIGN TIDE

The design tide elevation selected for the West Beach at Sherwood Island State Park is 11.0 feet above mean low water (4.0 feet above mean high water). This tide is estimated to occur with a frequency of once in two years. It was selected as the maximum level that should be considered.

DESIGN WAVE

The design wave is a 6.0-foot high breaking wave. It is the largest significant wave height that is expected to occur at the site. It was used for the design of the groin structure and the sandfill. The design wave was determined by application of Equations (1) and (2) as recomended in coastal Engineering Technical Note 1-6, Revised Method for Wave Forecasting in shallow Waters, dated March 1981. Table 4-4 is a summary of information pertinent to the selection of the design wave. Sherwood Island's West Beach is exposed to direct wave attack from the ESE through the SSW. In addition, diffracted waves originating from the east also attacked the beach. Fetch distances vary from 12.5 to 50 miles. Long Island limits the fetch distances for waves approaching the beach. Therefore, the West Beach is not subject to open ocean wave attack. The water depth varies considerably throughout Long Island Sound. Therefore, the depths shown in Table 4-4 are considered representative for their respective directions from the beach. A wind velocity of 40 mph was chosen for the design wind speed because that is the highest sustained

speed which is likely to occur in this area. Higher velocities do occur, but either the wind direction or speed is not maintained. Calculated durations required to build the signficiant wave height and significant wave height range from a low of 4.0 feet from the south to a high of 8.5 feet from the east. A diffraction analysis was completed for the 8.5 foot wave from the east. A diffraction diagram is shown on Plate 4-2. The diffracted wave height at the head of the groin structure is less than 2.0 feet. Therefore, the 6.0 foot, 5.0 second was from the ESE was chosen as the design wave for the groin structure and sandfill.

The erosion of a beach is caused by waves and currents acting in the surf zone. There is a need for wind, wave and nearshore current data in order to describe the sand transport process in the surf zone and to design coastal structures that are functionally and structurally successful. A technique for gathering this data is known as the Littoral Environmental Observation (LEO) Program.

The LEO Program provides data on nearshore waves, longshore and rip currents, wind conditions, and beach conditions. It also provides data for estimating longshore sand movement and for the preliminary design of coastal projects. Visual measurements are taken of breaker height, wave period, direction of wave approach, wind speed, wind direction, longshore current velocity, beach slope, and whether or not beach cusps and rip currents are present. This data is obtained using inexpensive equipment such as a wind meter for wind speed, a hand level for the foreshore slope and a dye to measure current speed and direction. These tests are conducted at the same time each day and at the same location without regard to the tide stage. The data that is collected relates longshore sand transport with wave conditions and allows a computation of sand transport based on longshore current velocities. This data will provide a good general picture of the physical environment at a site.

GROIN DESIGN

DESIGN PARAMETERS

The design of the low-profile groin structure was based on the following criteria:

1. Stillwater elevation of 11.0 feet above mean low water.
2. Side slopes of 1 vertical on 1.5 horizontal.
3. 6.0-foot breaking wave (entire structure).

4. KD coefficient of 2.0.

5. Stone unit weight of 165 pcf.

WEIGHTS OF STONE

The minimum weight of armor stone was determined from the following formula:

$$W = \frac{WrH^3}{KD(Sr-1)^3 \cot \theta}$$

where:

W = the weight of the armor stone, in pounds.

Wr = the unit weight of stone, in pcf.

KD = a dimensionless, experimental coefficient.

H = the design wave height, in feet.

Sr = the specific gravity of the armor stone relative to seawater ($= \frac{Wr}{Ww}$)

Ww = the unit weight of seawater, 64 pcf.

θ = the angle of the structure's side slopes measured from the horizontal, in degrees

The armor stone will range from 1.25 to 2.0 tons with 75% of the total weight composed of stones weighing 1.5 tons or more. The core and bedding stone will be composed of assorted sizes of stone up to 400 pounds with 50% of the total weight composed of stones weighing 300 pounds or more.

CONSTRUCTABILITY

The height of the groin is so low that construction of a two layer thickness of armor stone would require a considerable amount of underwater excavation in varying water depths. Most of this newly placed stone would be covered over with sandfill for the beach berm and slope. In order to eliminate this expensive excavation and additional stone, the armor layer will be only one stone width in thickness, 3.5 feet. To insure the stability of the structure, the KD valve has been decreased as recommended in the Shore Protection Manual. A KD valve of 2.0 for the strucure head

was used. Additionally, in order to simplify construction of the groin and because there is only one relatively short structure, the entire length will be composed of the same weights of armor stone. That is, the same stone weights that are required for the head of the structure will be used for the trunk. This will reduce the number of different weight classifications of stone and, at the same time provide a larger factor of safety for most of the structures length to help offset possible effects of the one armor stone layer thickness.

WAVE RUNUP

Computations for wave run up were made for storms that would occur at the design stillwater elevation of 11.0 feet above mean low water. A design slope of 1 vertical on 15 horizontal was used for the beach face based on recent surveys that showed this as the average slope that occurs naturally on the beach. Wave run up was computed and is expected to exceed the beach berm elevation of 12.0 feet MLW by 0.5 feet. This overtopping is not expected to cause any serious erosion of beach material primarily because of the addition of the low-profile groin structure. There could be some minor redistribution of sandfill but the material is expected to remain within the developed berm area. This is possible due to the ability of the existing west groin and the new low-profile to compartmentalize the beach and, therefore, reduce the alongshore and offshore losses.

GROIN CREST WIDTH, LENGTH, AND ELEVATION

The top width of the groin structure will be 10.0 feet for the entire 460 feet. The structure will extend beyond the toe of the proposed sandfill approximately 25 feet. The elevation of the seaward 100 feet of the structure will be at elevation 4.5 feet MLW and the landward 240 feet will be at elevation 12.0 feet MLW. The transition between these elevations will be approximately 120 feet long. The elevation of the head of the structure was designed to withstand the forces of the design wave and to provide a stable structure. The structure, also will compartmentalize the placed sandfill. The existing groin structure, located at the west limit of the study, was built in a similar manner and has functioned satisfactorily for the past 25 years. The 12.0 feet MLW elevation of the landward end of the structure was chosen to coincide with the top elevation of the proposed sandfill and the slope of the transition will be the top elevation of the proposed sandfill. (See Plate 4-1.)

The landward portion of the existing structure (approximately 250 feet), located at the west limit of the beach will be lowered to elevation 13.0 feet MLW. The exact length will be determined during plans and specifications.

HISTORIC HIGH WATER SHORELINE

The shores of the New England beaches have historically extended many hundreds of feet seaward of the present location. The mean high waterline at Sherwood Island is no exception. Research of historic photos and plot plans has indicated that the high water shoreline was seaward of its present position. More significant than this historic information is the need to design and engineer a project to provide protection to the backshore from future erosion and healthful recreational use. Of the six considered plans, the most practicable and economical plan for Sherwood Island is beach widening by the direct placement of suitable sandfill and one low profile groin structure. Two other plans that were considered but eliminated from our detailed analysis and did not directly involve the historic highwater shoreline, but proved to be very expensive were: a breakwater located approximately 2000 feet offshore and rock revetment extending along the backshore for the entire length of West Beach to prevent further erosion of the backshore park and picnic area. The benefits derived from the breakwater and revetment plan are minimal with no economic justification to proceed with construction. Sherwood Island is a State owned and operated public park, used for swimming, picnicking and other recreational activities for everyone on an equal basis. The most practical and economical engineering solution to prevent further erosion of the backshore area and provide a healthful recreational beach bathing area is to place suitable sandfill on the beach thereby extending the present mean high waterline seaward to provide protection to the eroding backshore from damaging waves. The benefits from this design are that the recreational use of the area will be preserved, and with annual periodic nourishment for the life of the project, erosion-causing forces will be restricted to areas seaward of the backshore, thereby preventing further loss of the valuable backshore grass and picnic area. This sandfill and low profile groin plan is more practical and considerably more economical than the breakwater or revetment plans.

SANDFILL

In the design of the sandfill, consideration was given to the existing sand on the beach and the requirements set forth in the 1977 "Shore Protection Manual." These requirements were established to be used as a guide in the design and construction of beaches and are dependent on the availability of materal from an offshore or a nearby land source wave climate, storm conditions, etc.

There are several suitable commercial land-based sand pits within 35 miles of Sherwood Island. Offshore sand sources for large quantities of material were not considered as primary sources at Sherwood Island's West Beach. Compo Cove, adjacent to West Beach, is a shallow area that the

State Department of Environmental Protection is planning to dredge. A small amount of the dredged material may be placed on the private Compo Beach; the remaining material could be used as a base or underlayer on West Beach, if it is environmentally acceptable. This dredged material, if placed on West Beach, will be covered with approximately 4.0 to 6.0 feet of a better quality material from a nearby land source.

This method of construction has been coordinated with the U.S. Army Coastal Engineering Research Center, Washington, D.C. A determination of whether or not to use this method of sandfill placement will be made prior to construction. The State of Connecticut has addressed the impacts of the offshore borrow area in their Environmental Impact Evaluation. Any cost reduction in the placement of sandfill on the beach between land-based sandfill and offshore sandfill will be included at the time of final plans and specifications.

The slope of the seaward face of the proposed sandfill was selected to be 1 vertical on 15 horizontal. This was selected in part because the slope of the existing intertidal zone varies considerably and is similar to other stable beaches in the area. The proposed beachfill will be of a better quality material than that which is already there, therefore, a steeper slope will be more stable for this climate. The horizontal level beach berm elevation of 12.0 feet above mean low water is the maximum practical elevation commensurate with the design stillwater elevation and wave run up and the natural backshore area.

The proposed slope is considered consistent with the natural slope; however, with the use of a better quality material, the beachfill could be placed on a slightly steeper slope within the tidal range and the wave action during construction will be allowed to distribute the material naturally. During construction the natural wave action will distribute the fill material as it is placed in the intertidal zone. Therefore, it was necessary to calculate sand volumes based on a profile that was considered consistant with the movement of material during the time of construction. Additional material is included in the estimated cubic yards of placed material to allow for losses during construction. Also included in the estimated cost is a contingency factor to allow for unexpected over runs. A construction profile is not included in this report because it has been our experience that the losses due to this wave action are not significant with the placement of a better quality beachfill material.

The sandfill should, within practical limits of the availability in the area, have a median diameter between 0.35 mm. and 1.0 mm. Not more than 5.0 percent of the material should be retained on the number 4 U.S. standard sieve and no more than 5.0 percent should be allowed to pass through the number 200 sieve. The material should also be uniformly graded; that is all the particles should have sizes that are close to the typical size. This gradation of sand is within the accepted criteria as set forth in the 1977 "Shore Protection Manual" for medium beach sand which is satisfactory to stabilize the beach and is well suited for beach

bathing purposes. Our preliminary sampling of the nearby land source pits indicates that material with these characteristics is available.

During construction, every precaution will be taken to assure that the contractor places the specified quality of sand on the beach. This will be accomplished by frequent sampling and testing of the material during construction. This in turn will reduce the impact in the offshore area. The sandfill should be placed during the months of April through June. No sand should be placed during the summer or winter months.

PERIODIC NOURISHMENT

Federal participation in the cost of periodic beach nourishment is recommended for the 50-year period of analysis. The project is designed with one low-profile groin structure to be used to compartmentalize the sandfill but not to interrupt the alongshore movement of littoral material. By periodically nourishing the beach, project alignment can be maintained and normal onshore and offshore losses that occur can be replaced. The cost of this nourishment will be shared on the same basis as the initial project cost sharing; that is 70 percent Federal and 30 percent non-Federal, not to exceed $1,000,000 of Federal project cost.

COST APPORTIONMENT

Federal participation in the costs of beach erosion control projects is based on shore ownership and use. Public-owned shore park and conservation areas are eligible for Federal cost sharing up to 70 percent of the construction cost providing the following criteria are met:

a. Must be publicly owned.

b. It includes a zone extending landward from the mean low water line which includes all permanent human habitation but not including the residences of park administrative and maintenance personnel.

c. It includes a beach suitable for recreational use.

d. It provides for preservation, conservation and development of the natural resources of the environment in accordance with the overall mission or purpose of the park.

e. Extend landward a sufficient distance to include protective dunes, bluffs or other natural features to absorb and dissipate wave energy and flooding effects of the design storm tide.

f. It provides essentially full park facilities for appropriate public use.

Sherwood Island State Park West Beach satisfies all of the above criteria, and therefore, is eligible for 70 percent Federal and 30 percent non-Federal cost sharing.

The apportionment of cost between Federal and non-Federal interests for the proposed improvement and periodic nourishment will be 70 percent and 30 percent, respectively. The apportionment of costs for the four considered plans are summarized in Tables 4-5 and 4-6 of this section. The currently estimated first cost of the selected plan at the current interest rate of 7 3/8 percent is $960,000. The Federal share of this cost is $672,000.

The apportionment of the first cost, annual charges and the cost of periodic nourishment for the selected plan are displayed below.

SHERWOOD ISLAND
PLAN 3 - 200' BERM

FIRST COST

Sandfill	90,000 cy(1) @ $7.00/cy		$630,000
Groin			
Armor	2,200 tons @ $25.00/ton		55,000
Core	1,500 tons @ $20.00/ton		30,000
		Subtotal	$715,000
	Contingencies		143,000
		Subtotal	$858,000
	Engineering and Design		42,000
		Subtotal	$900,000
	Supervision and Administration		50,000
		Subtotal	$950,000
	Lowering Existing Groin (L.S.)		10,000
		TOTAL FIRST COST	$960,000

(1) Includes the quantities for first year of periodic nourishment

COST SHARING

Federal Share (70%)	$672,000
Non-Federal Share (30%)	$288,000

Periodic Nourishment for 49 Years of 50 Years Life of Project $21,000/yr.

*Federal Share (70%)	$ 720,300	
Non-Federal Share (30%)	308,700	
	$1,029,000	1,029,000
	TOTAL PROJECT COST	$1,989,000

ANNUAL CHARGES

Federal Investment	
Interest - 0.07375 X $672,000	$ 49,500
Amortization 0.00216 X $672,000	1,600
Periodic Nourishment - Sandfill 2,100 cy @ $7.00/cy	14,700
Total Federal	$ 65,800
Non-Federal Investment	
Interest - 0.07375 X $288,000	$ 21,300
Amortization 0.00216 X $288,000	600
Periodic Nourishment - Sandfill 900 cy @ $7.00/cy	6,300
Groins, Maintenance 40 tons @ $25.00/ton	1,000
Total Non-Federal	$ 29,200
TOTAL ANNUAL CHARGES	$ 95,000

* The Federal share in periodic nourishment, construction, and study costs for the period of analysis; cannot exceed the $1,000,000 Federal limitation. Current estimates indicate that approximately $200,000 is available for the Federal share in the periodic nourishment.

FIGURE 4-1

APPROXIMATE
TIDAL DATUM PLANES
SHERWOOD ISLAND STATE PARK BEACH

(BASED UPON CURRENTLY AVAILABLE SHORT TERM DATA FROM NEARBY NATIONAL OCEAN SURVEY TIDAL BENCHMARK LOCATIONS)

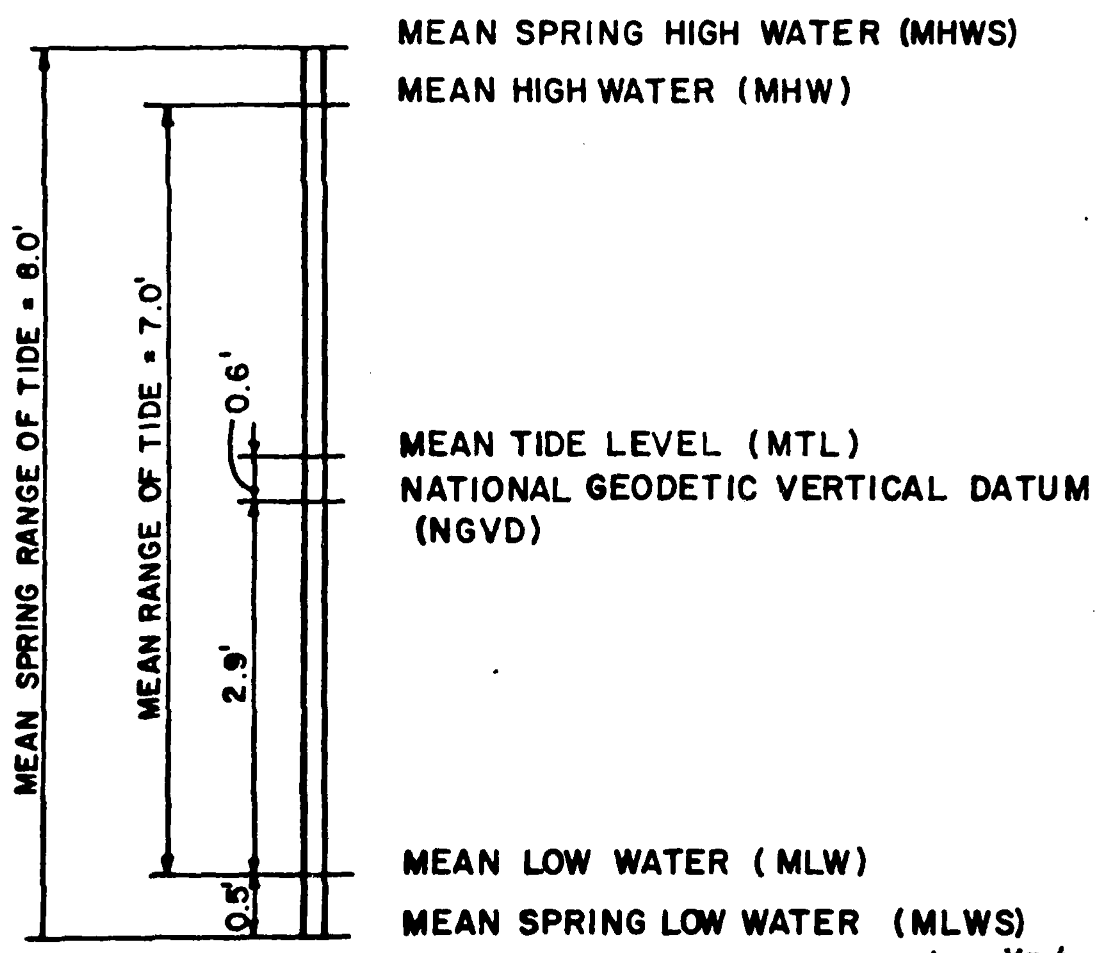
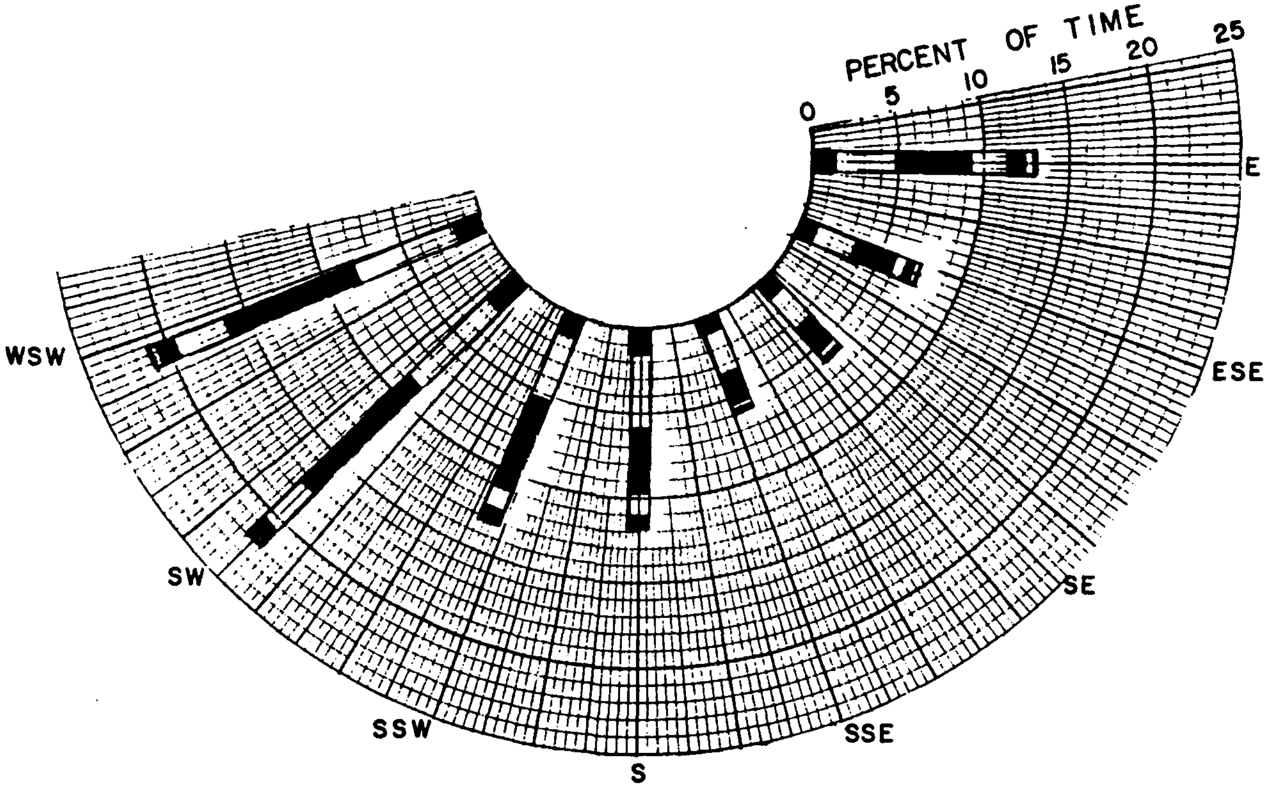
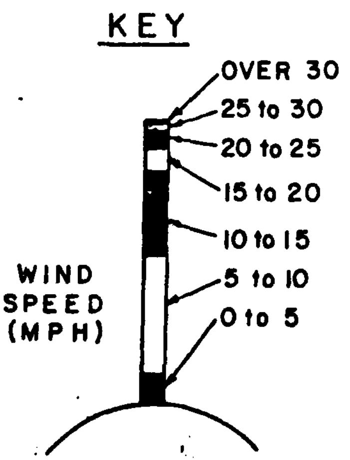


FIGURE 4-2

BRIDGEPORT, CONNECTICUT
NATIONAL WEATHER SERVICE
TRI-HOURLY WIND OBSERVATIONS BETWEEN E AND WSW

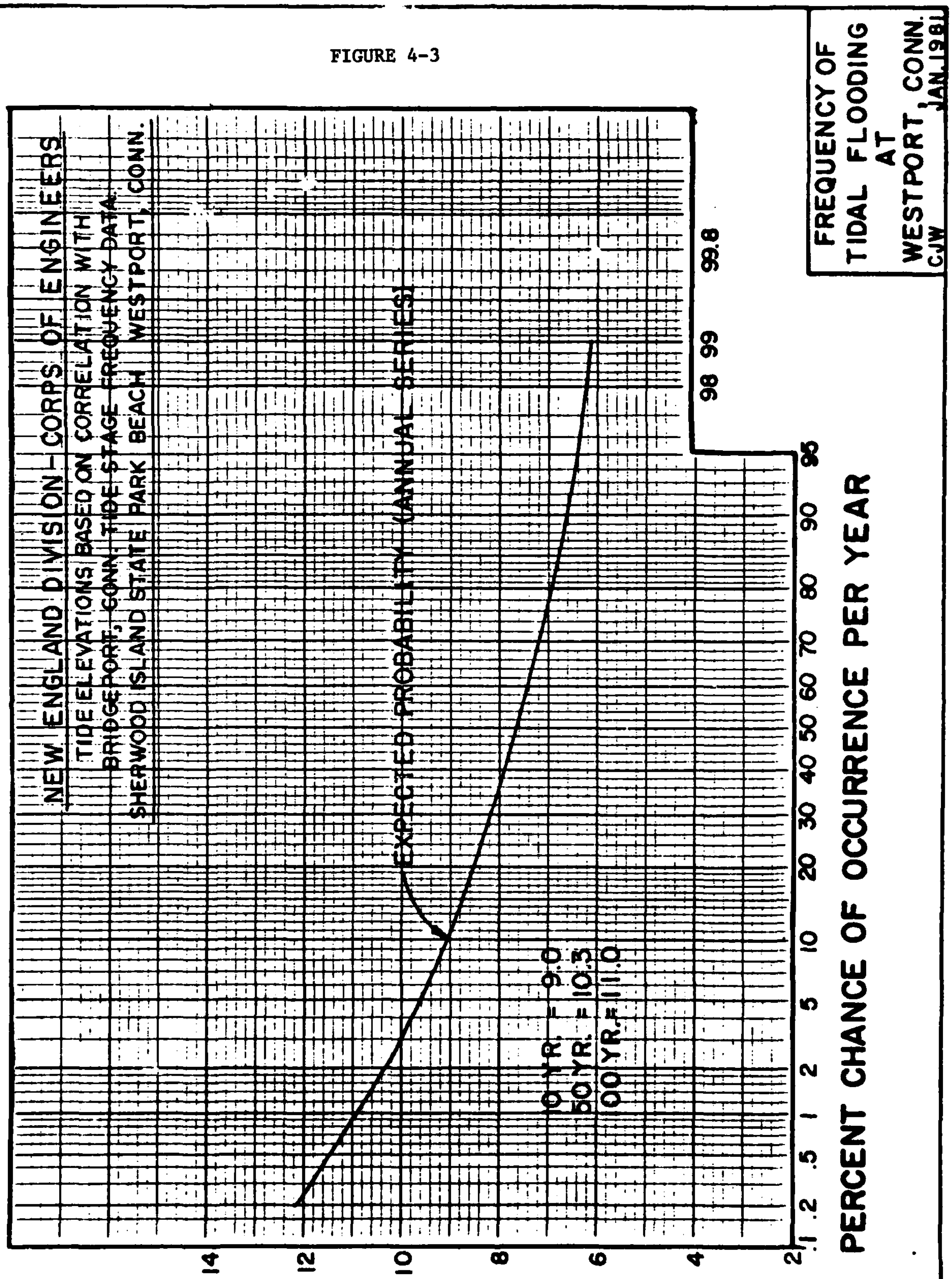
PERCENT OCCURRENCE OF WIND SPEED AND DIRECTION





NOTE:
PERCENT OF TIME FOR EACH RANGE OF WIND SPEED IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH.

FIGURE 4-3



FREQUENCY OF TIDAL FLOODING AT WESTPORT, CONN.
CJW JAN.1981
NEW ENGLAND DIVISION-CORPS OF ENGINEERS
TIDE ELEVATIONS BASED ON CORRELATION WITH BRIDGEPORT, CONN. TIDE STAGE FREQUENCY DATA.
SHERWOOD ISLAND STATE PARK BEACH WESTPORT, CONN.
EXPECTED PROBABILITY (ANNUAL SERIES)
10 YR. = 9.0
50 YR. = 10.3
100 YR. = 11.0
PERCENT CHANCE OF OCCURRENCE PER YEAR
STILLWATER ELEVATION (FT.,NGVD)
.1
.2
.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.8
2
4
6
8
10
12
14

TABLE 4-1

BRIDGEPORT, CONNECTICUT
NATIONAL WEATHER SERVICE
TRI-HOURLY WIND OBSERVATIONS BETWEEN E AND WSW

(a)

PERCENT OCCURRENCE OF WIND DIRECTION FOR
VARIOUS WIND SPEED RANGES

	Wind Speed Range (MPH)									
Direction	0-5	5-10	10-15	15-20	20-25	25-30	Over 30	All Inclusive	Avg. Speed	Max. Speed
E	12	11	12	15	21	29	40	13	12.8	57.5
ESE	9	8	7	6	7	9	5	7	11.0	34.5
SE	10	7	5	3	3	2	2	6	9.5	49.5
SSE	9	8	5	3	3	3	2	6	9.6	36.8
S	14	14	11	9	10	8	13	12	10.7	48.3
SSW	12	12	13	15	15	12	9	13	11.9	39.1
SW	19	20	24	25	18	14	8	22	11.5	42.6
WSW	15	20	23	24	23	23	21	21	12.0	57.5

(b)

RESULTANT WIND DIRECTION
AND
PERCENTAGE OF OBSERVATIONS
FOR VARIOUS WIND SPEED RANGES

	Observation of Wind Speed (MPH)							
	0-5	5-10	10-15	15-20	20-25	25-30	Over 30	All Inclusive
Resultant Direction:	S	S	SSW	SSW	S	S	SSE	SSW
Percent of Observations:	11	32	36	14	5	2	Under 1	100

Note: Wind speed ranges indicated include values greater than the lower limit and up to, and including the higher limit.

TABLE 4-2

BRIDGEPORT, CONNECTICUT
NATIONAL WEATHER SERVICE
TRI-HOURLY WIND OBSERVATIONS
DAYS OF MAXIMUM TIDAL FLOODS

Date	Maximum Speed (mph)	Direction
21 Sep 38*	-	-
31 Aug 54	33.4	NE
14 Sep 44*	-	-
25 Nov 50	57.5	E
7 Nov 53	28.8	NE
12 Sep 60	39.1	NW
14 Oct 55	46.0	ENE
19 Feb 60	34.5	WNW
12 Nov 68	43.7	ENE
13 Apr 61	51.8	E
6 Mar 62	42.6	E
30 Nov 44*	-	-
4 Apr 73	43.7	E
20 Mar 58	28.8	NE
21 Sep 61	46.0	NE
10 Nov 62	31.1	E
16 Feb 58	40.3	E
31 Oct 47	29.9	NNE
12 Mar 59	35.7	E
14 Feb 60	40.3	WNW
19 Feb 72	31.1	NE
26 Dec 69	36.8	ENE
2 Dec 74	29.9	ENE
19 Mar 61	13.8	ENE
16 Sep 71	9.2	SSE
29 Dec 66	25.3	WNW
27 Nov 40*	-	-
29 Nov 45*	-	-
8 Dec 50*	27.6	E
4 Feb 61	34.5	NE

* Wind data not available

(Events are listed in order of decreasing stillwater tide level to conform with Table 4-3).

TABLE 4-3

BRIDGEPORT, CONNECTICUT
MAXIMUM OBSERVED TIDE LEVELS
(1938 - 1975)

Date	Observed Stillwater Elevation (ft. NGVD)	Adjusted* Elevation (ft. NGVD)	Recurrence** Interval
21 Sep 1938 (Hurricane)	9.2	9.6	56
31 Aug 1954 (Hurricane-Carol)	9.2	9.4	40
14 Sep 1944 (Hurricane)	8.8	9.1	28
25 Nov 1950	8.8	9.0	23
7 Nov 1953	8.6	8.8	18
12 Sep 1960 (Hurricane-Donna)	8.2	8.3	9
14 Oct 1955	7.9	8.1	7
19 Feb 1960	7.9	8.0	6
12 Nov 1968	7.8	7.9	5
13 Apr 1961	7.7	7.8	4
6 Mar 1962	7.7	7.8	4
30 Nov 1944	7.4	7.7	4
4 Apr 1973	7.4	7.4	3
20 Mar 1958	7.3	7.4	3
21 Sep 1961 (Hurricane-Esther)	7.3	7.4	3
10 Nov 1962	7.3	7.4	3
16 Feb 1958	7.3	7.4	3
31 Oct 1947	7.2	7.4	3
12 Mar 1959	7.2	7.3	2
14 Feb 1960	7.2	7.3	2
19 Feb 1972	7.3	7.3	2
26 Dec 1969	7.2	7.3	2
2 Dec 1974	7.2	7.2	2
19 Mar 1961	7.1	7.2	2
16 Sep 1971	7.1	7.1	2
29 Dec 1966	7.0	7.1	2
27 Nov 1940	6.8	7.1	2
29 Nov 1945	6.8	7.1	2
8 Dec 1950	6.8	7.0	2
4 Feb 1961	6.8	6.9	2

*Observed values after adjustment for rising sea level; adjustment made to 1975 sea level conditions based on NOS publication "Trends and Variability of Yearly Mean Sea Level, 1893-1972".

**Based upon Pearson Type III expected probability tide stage-frequency relationship for Bridgeport, determined for the adjusted annual maxium stillwater tide levels.

TABLE 4-4

DEEP WATER WAVE HEIGHTS THEORY

Direction	E	ESE	SE	SSE	S	SSW
Fetch Distance (Miles)	50.0	27.0	14.0	15.0	12½	14.0
Water Depth (d in Feet)	50.0	75.0	75.0	65.0	60.0	30.0
Wind Velocity (Ua in M.P.H.)	40.0	40.0	40.0	40.0	40.0	40.0
Duration (Hours)	3.7	2.8	1.9	2.5	2.1	2.3
Significant (1) Wave Height (Hs)	8.5 (.2) (2)	6.0	4.5	4.5	4.0	4.5
Significant Wave Period (T in Seconds)	5.6	5.0	4.2	4.7	4.4	4.6

(1) Transitional wave analysis as contained in CETN-I-6 dated 3/81.
(2) Diffracted wave height.

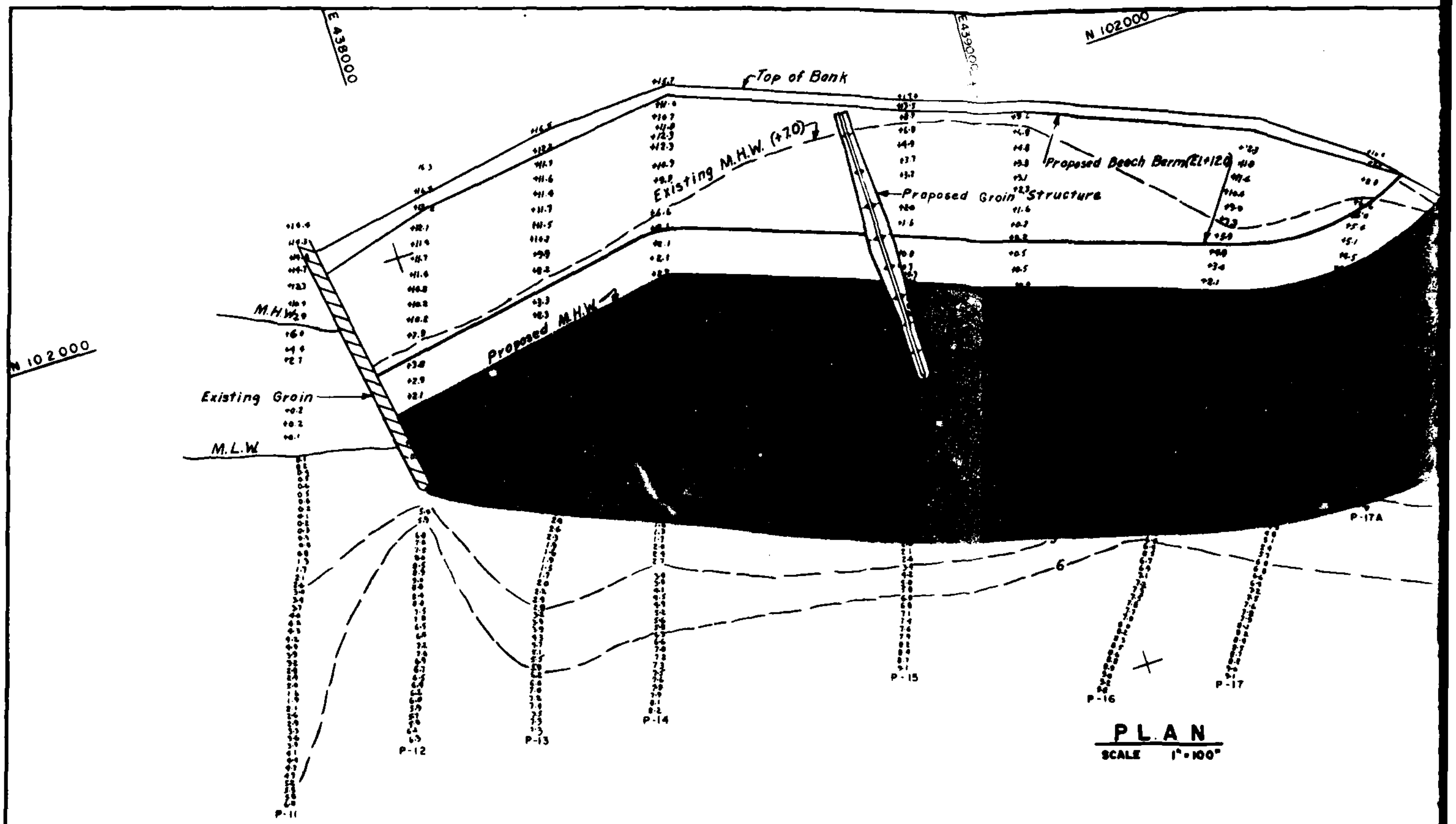
TABLE 4-5
BENEFITS AND COSTS FOR CONSIDERED PLANS

PLAN	BERM WIDTH	TOTAL FIRST COST	SHERWOOD ISLAND 70/30 COST SHARING				ANNUAL BENEFITS	ANNUAL COST	B/C RATIO	NET BENEFITS
			$ COST SHARING		$ ANNUAL COST					
			FEDERAL	NON-FED	FEDERAL	NON-FED				
1	200	833,000	583,000	250,000	72,000	31,000	718,600	103,000	6.98	615,600
	225	947,000	663,000	284,000	118,000	50,500	788,600	168,500	4.68	620,100
	250	1,098,000	768,500	329,500	188,000	80,500	888,600	268,500	3.31	620,100
2	200	838,000	586,500	251,500	72,500	31,000	725,800	103,500	7.01	622,300
	225	952,000	666,500	285,500	118,000	51,000	796,500	169,000	4.71	627,500
	250	1,103,500	772,500	331,000	188,500	80,500	897,500	269,000	3.34	628,500
3	200	960,000	672,000	288,000	65,800	29,200	734,800	95,000	7.73	639,800
	225	1,092,500	765,000	327,500	104,000	49,000	805,500	153,000	5.26	652,500
	250	1,257,000	880,000	377,000	157,000	79,000	906,500	236,000	3.84	670,500
4	N/A	76,500	53,500	23,000	7,500	3,200	4,000	10,700	.37	0

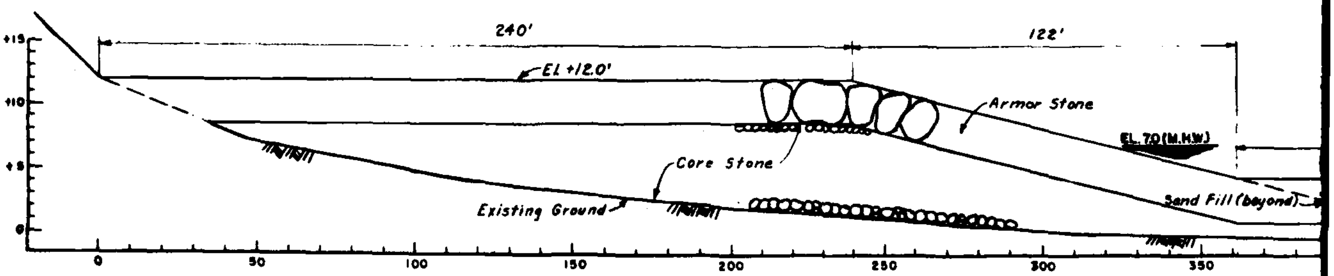
TABLE 4-6
COST APPORTIONMENT FOR CONSIDERED PLANS

PLAN	BERM WIDTH	SHERWOOD ISLAND 70-30 COST SHARING					
		$ COST SHARING		$ ANNUAL COST		$ PERIODIC NOURISHMENT	
		FEDERAL	NON-FED	FEDERAL	NON-FED	FEDERAL	NON-FED
1	200	583,000	250,000	72,000	31,000	35,280	15,120
	225	663,000	284,000	118,000	50,500	88,200	37,800
	250	768,500	329,500	188,000	80,500	170,520	73,080
2	200	586,500	251,500	72,500	31,000	35,280	15,120
	225	666,500	285,500	118,000	51,000	88,200	37,800
	250	772,500	331,000	188,500	80,500	170,520	73,080
3	200	672,000	288,000	65,800	29,200	14,700	6,300
	225	765,000	327,500	104,000	49,000	58,800	25,200
	250	880,000	377,000	157,000	79,000	117,600	50,400
4*	N/A	53,500	23,000	7,500	3,200	0.0	4,200

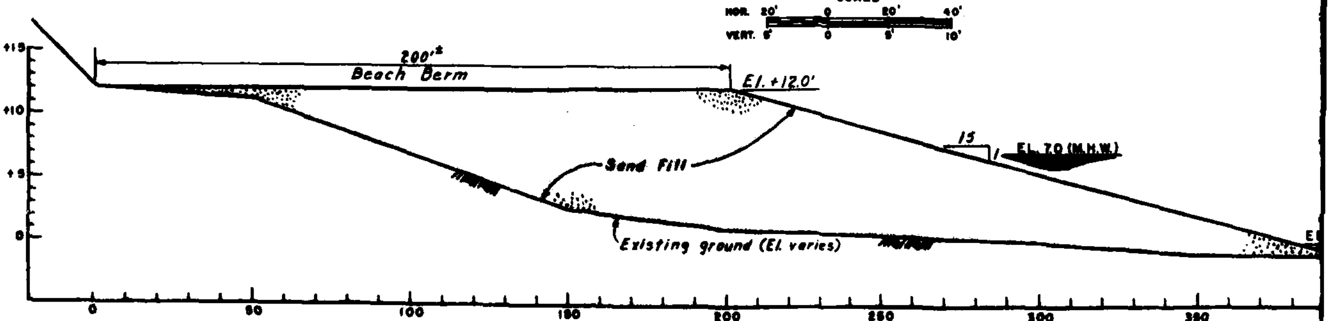
* - Lump Sum Quantities based on 1981 Levels.



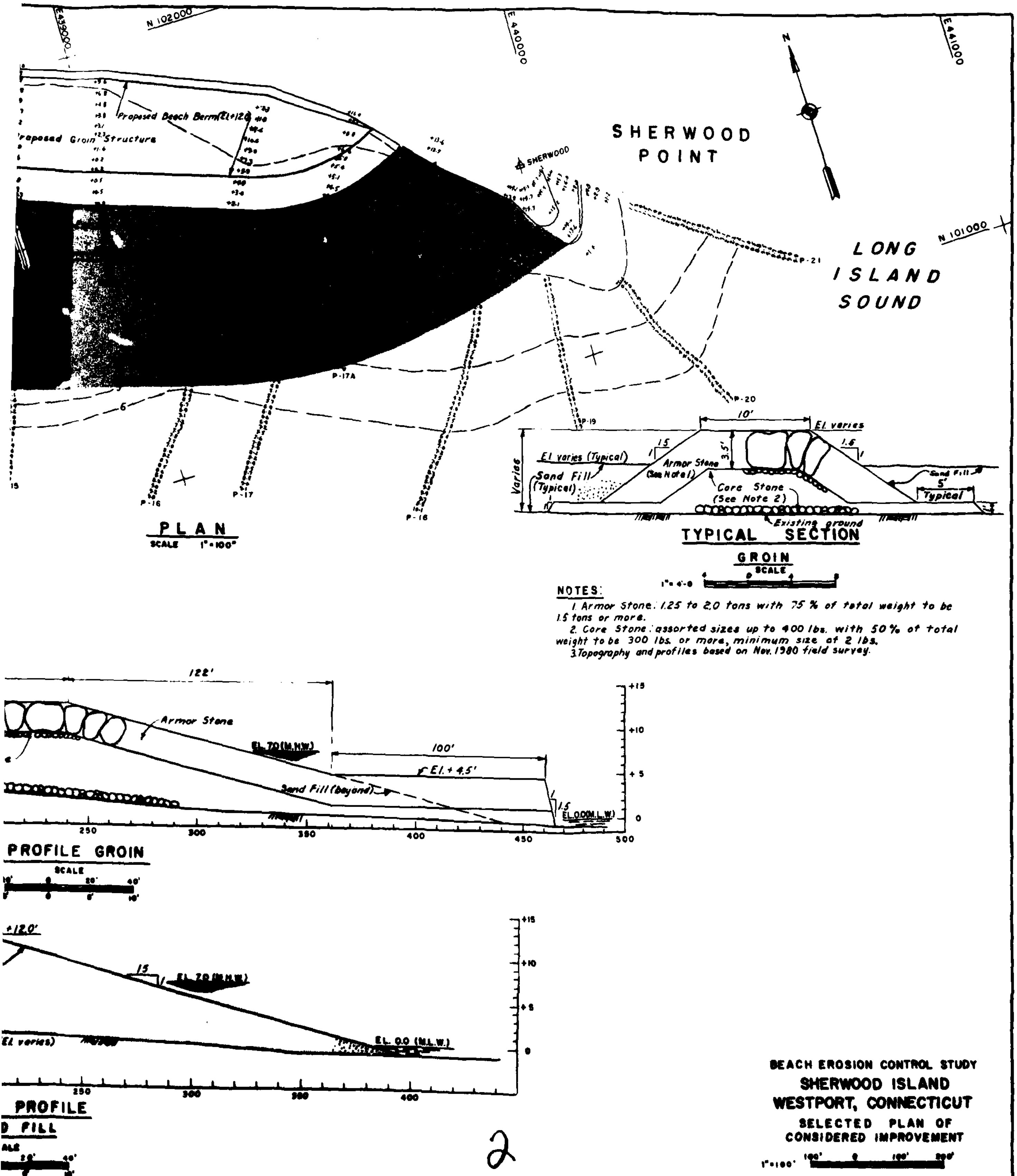
PLAN
SCALE 1" = 100'



℄ PROFILE GROIN
SCALE
HOR. 20' 0 20' 40'
VERT. 5' 0 5' 10'



TYPICAL PROFILE
SAND FILL
SCALE
HOR. 20' 0 20' 40'
VERT. 5' 0 5' 10'



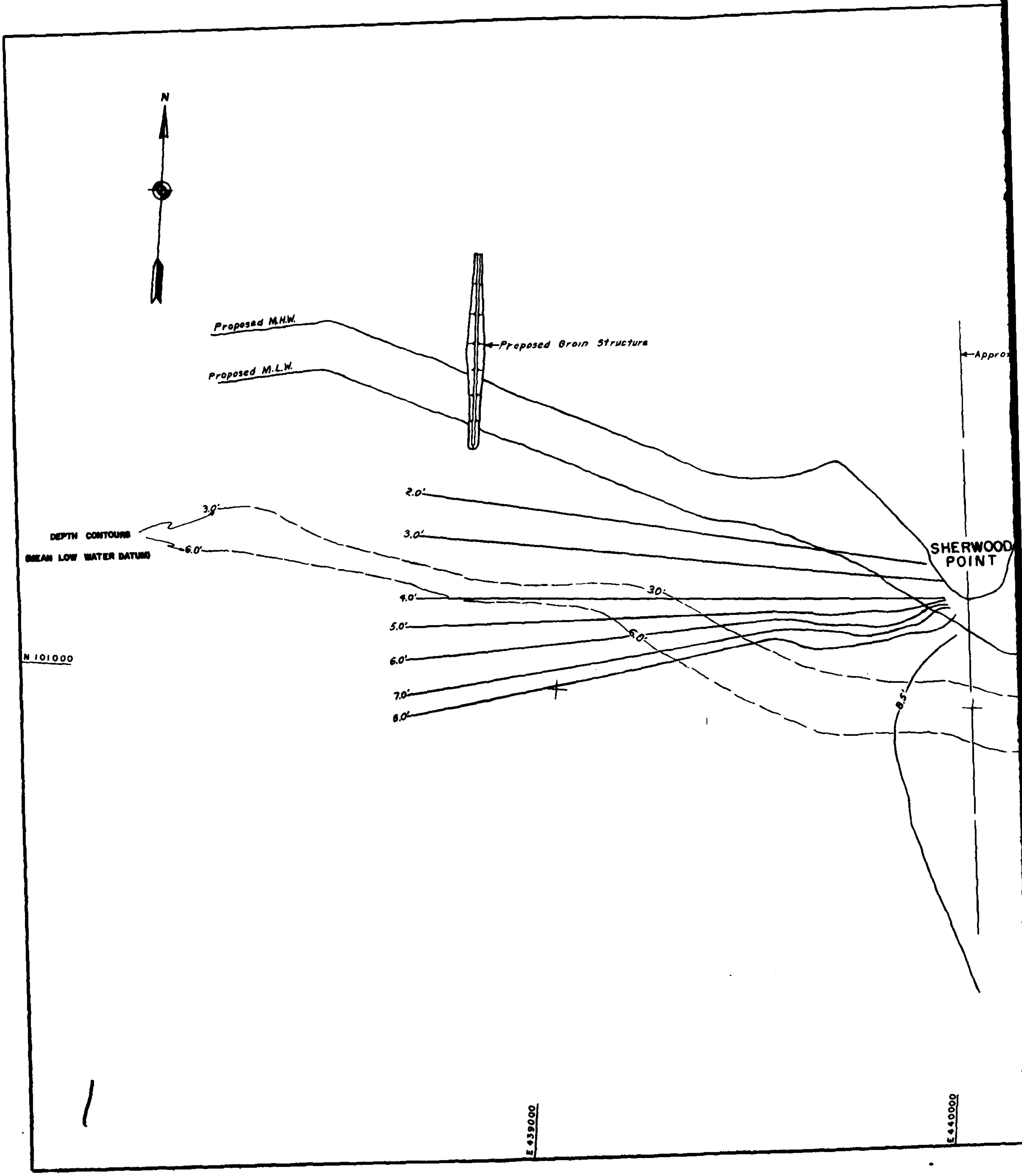
2

BEACH EROSION CONTROL STUDY
SHERWOOD ISLAND
WESTPORT, CONNECTICUT
SELECTED PLAN OF
CONSIDERED IMPROVEMENT

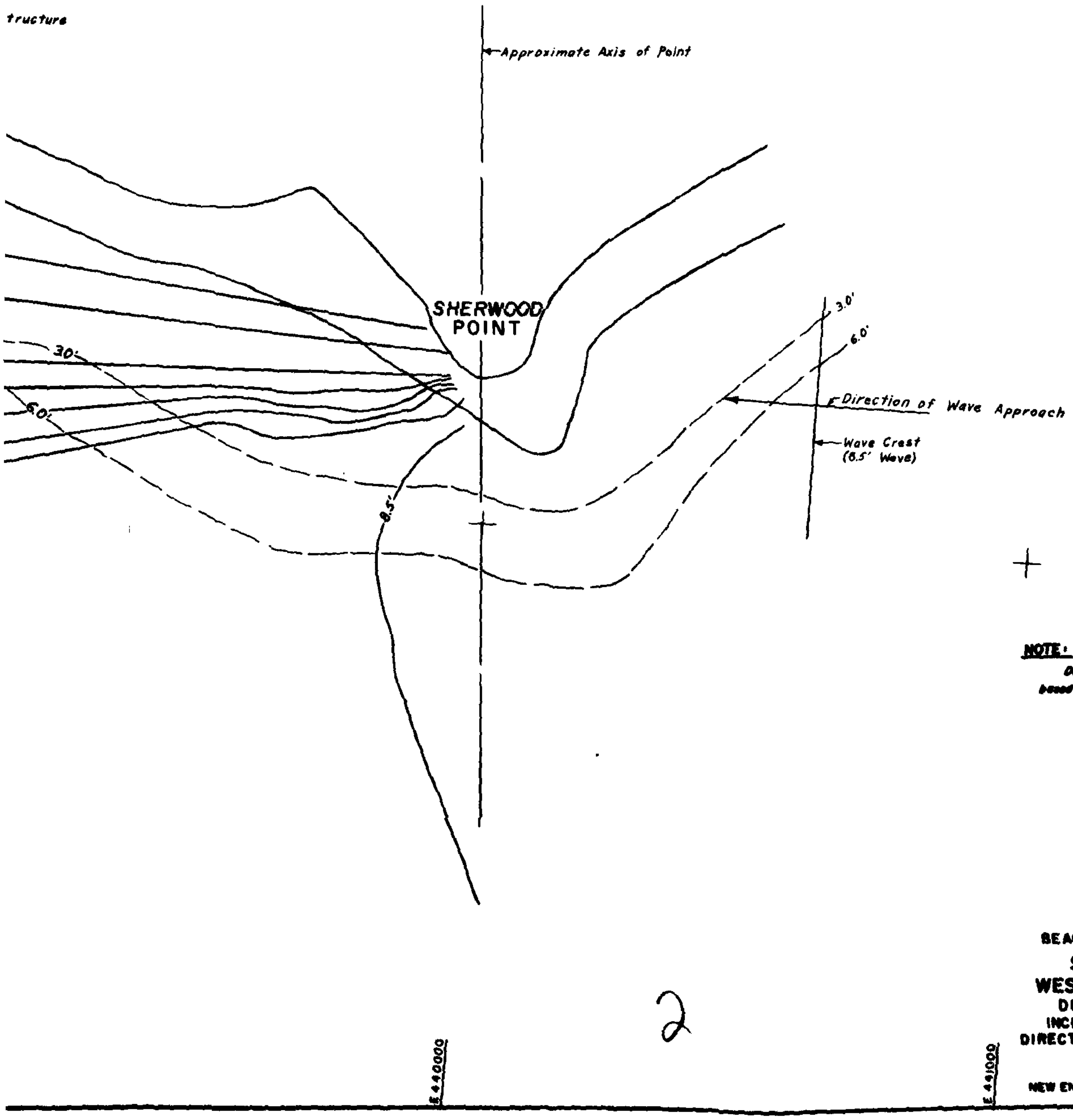
1" = 100'

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 4-1



N
Proposed M.H.W.
Proposed M.L.W.
Proposed Groin Structure
Approx
DEPTH CONTOURS
(MEAN LOW WATER DATUM)
3.0'
6.0'
2.0'
3.0'
4.0'
5.0'
6.0'
7.0'
8.0'
3.0'
6.0'
8.5'
SHERWOOD
POINT
N 101000
E 439000
E 440000

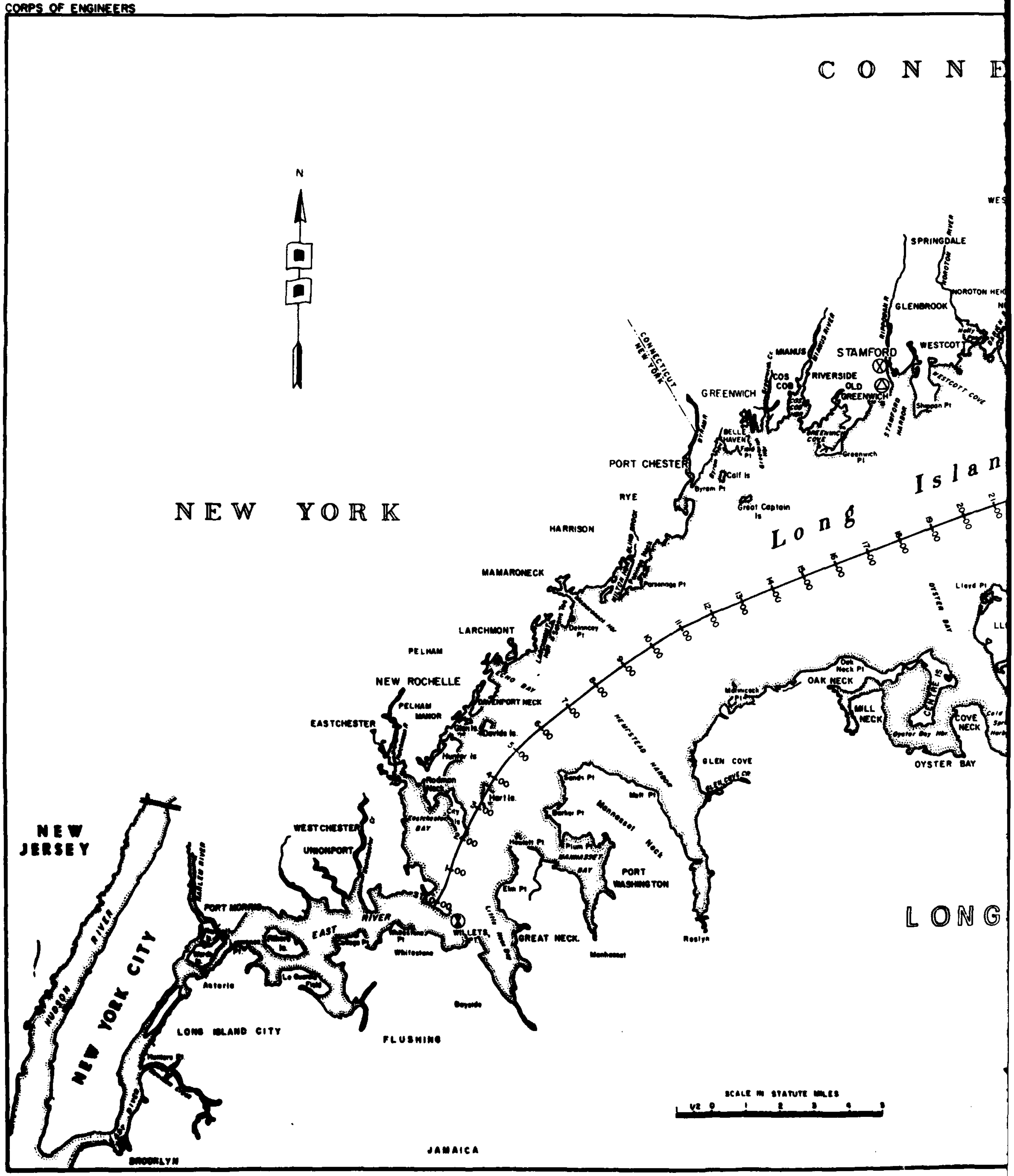


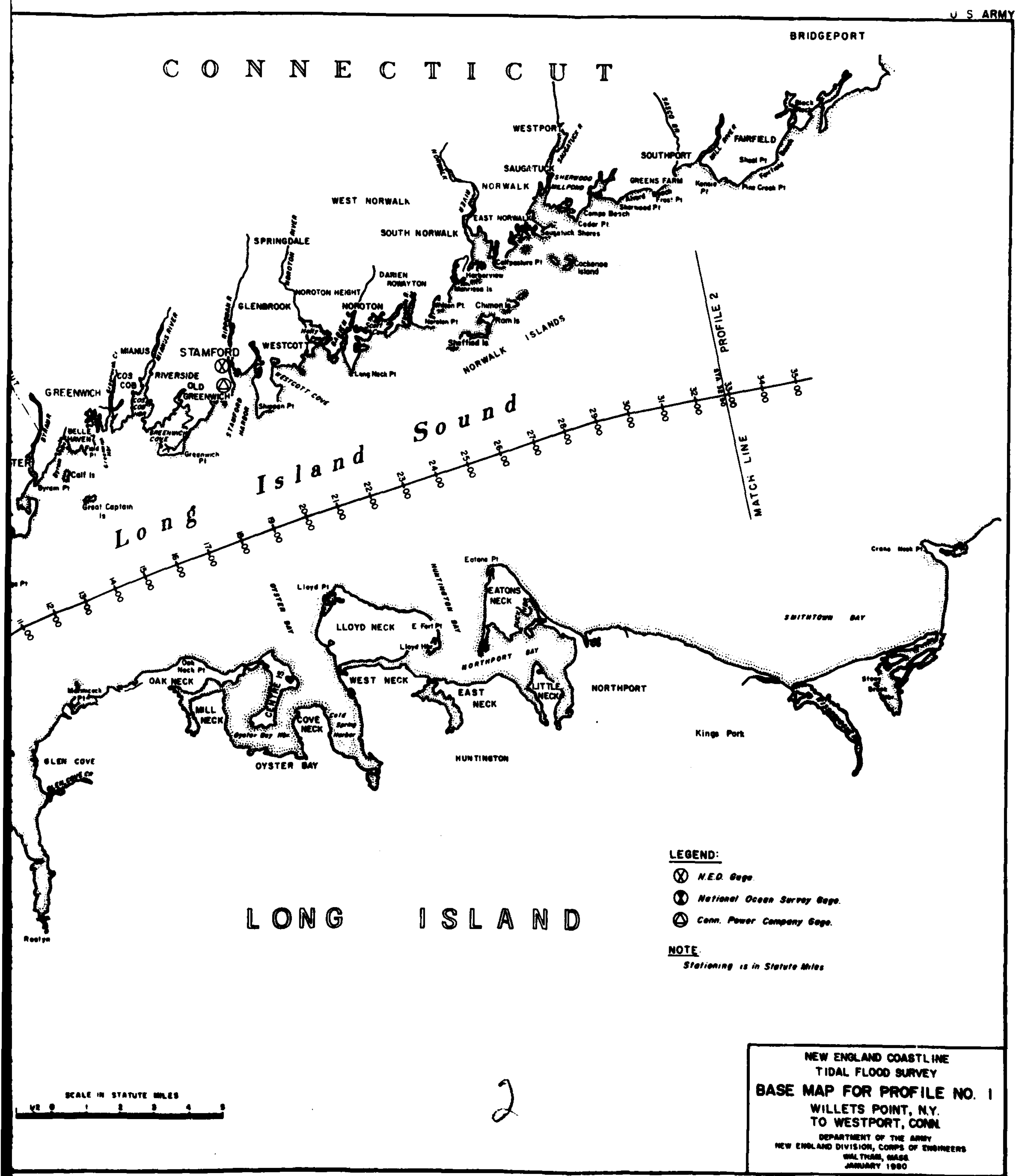
NOTE:
Diffracted wave heights based on an 8.5 ft incident wave.

BEACH EROSION CONTROL STUDY
SHERWOOD ISLAND
WESTPORT, CONNECTICUT
DIFFRACTION DIAGRAM
INCIDENT WAVE HEIGHT = 8.5
DIRECTION OF WAVE APPROACH - E
100' 0 100' 200'
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 4-2

CORPS OF ENGINEERS

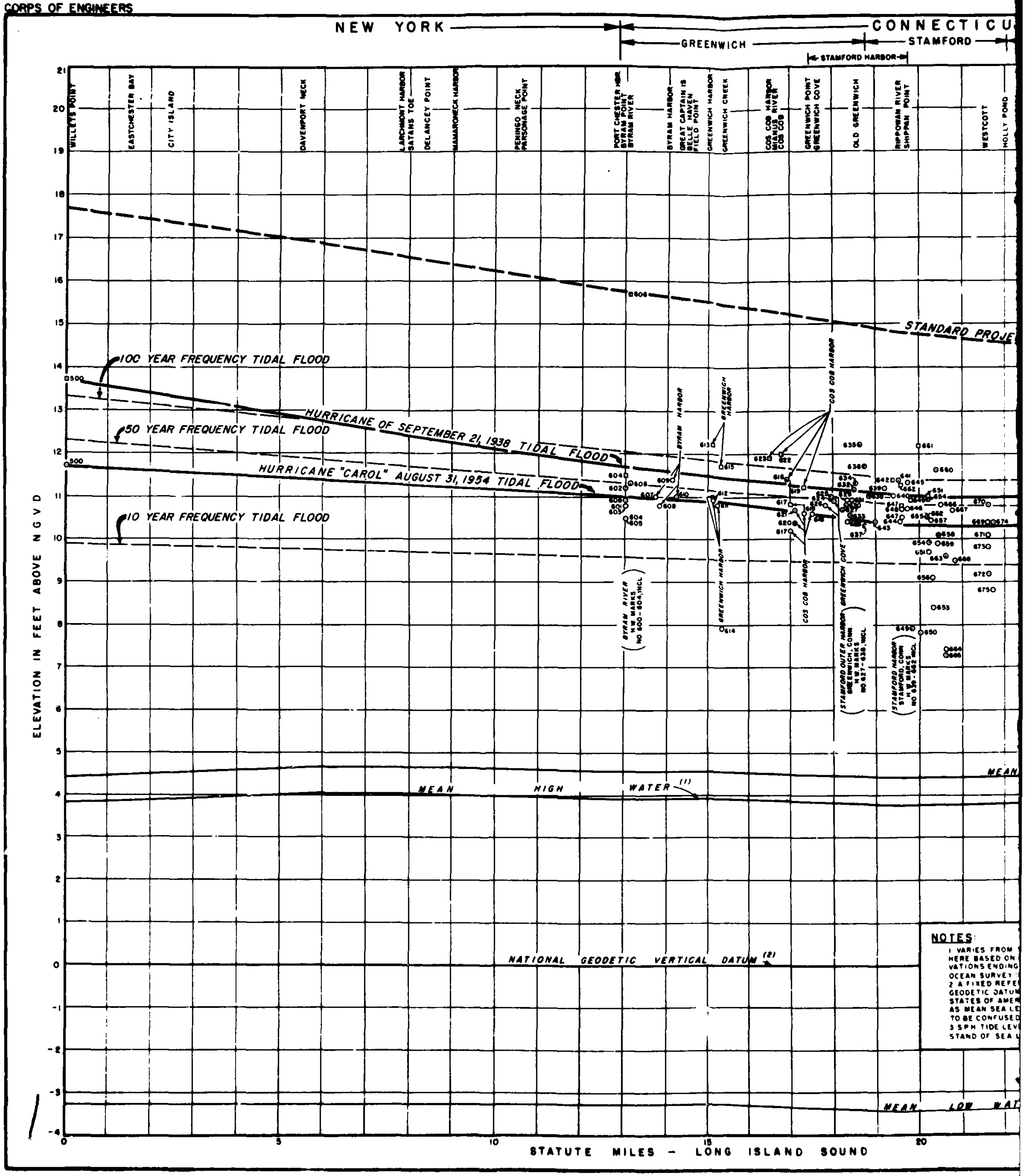


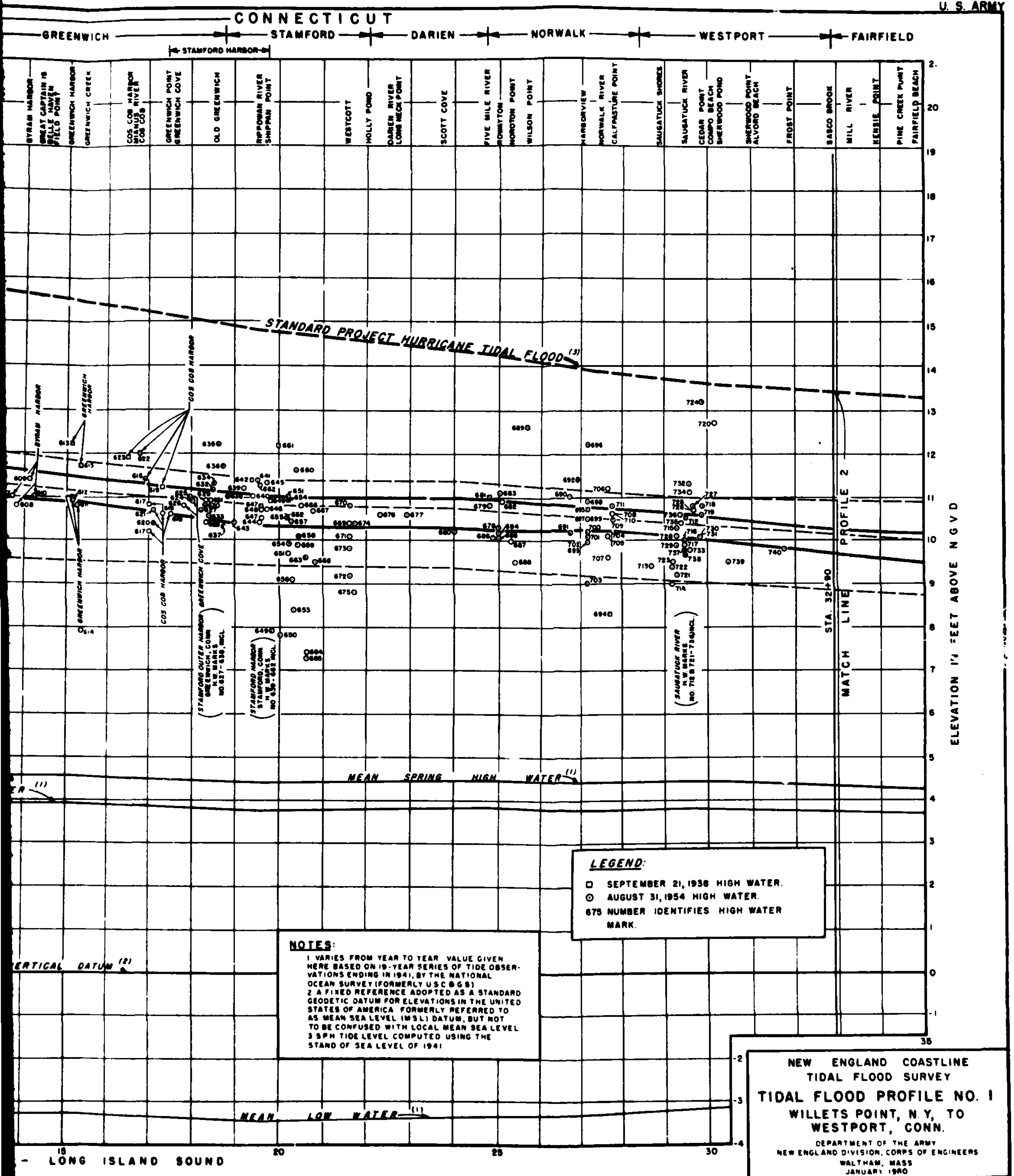

U S ARMY
BRIDGEPORT
CONNECTICUT
WESTPORT
SAUGATUCK
NORWALK
WEST NORWALK
SOUTHPORT
FAIRFIELD
GREENS FARM
EAST NORWALK
SOUTH NORWALK
SPRINGDALE
DARIEN
ROWAYTON
NOROTON HEIGHT
NOROTON
GLENBROOK
STAMFORD
WESTCOTT
MIANUS
COS COB
RIVERSIDE
OLD GREENWICH
GREENWICH
BELLE HAVEN
NORWALK ISLANDS
Cockenoe Island
Chimon Is
Sheffield Is
Great Captain Is
Calf Is
Long Island Sound
PROFILE 2
MATCH LINE
Lloyd Pt
Eatons Pt
EATONS NECK
LLOYD NECK
OYSTER BAY
HUNTINGTON BAY
SMITHTOWN BAY
Crane Neck Pt
NORTHPORT BAY
NORTHPORT
WEST NECK
EAST NECK
LITTLE NECK
OAK NECK
MILL NECK
CENTRE IS
COVE NECK
Cold Spring Harbor
OYSTER BAY
HUNTINGTON
Kings Park
GLEN COVE
Roslyn
LONG ISLAND
LEGEND:
N.E.D. Gage.
National Ocean Survey Gage.
Conn. Power Company Gage.
NOTE:
Stationing is in Statute Miles
SCALE IN STATUTE MILES
1/2 0 1 2 3 4 5
NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR PROFILE NO. 1
WILLETS POINT, N.Y.
TO WESTPORT, CONN.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
JANUARY 1980

2

PLATE 4-3

CORPS OF ENGINEERS

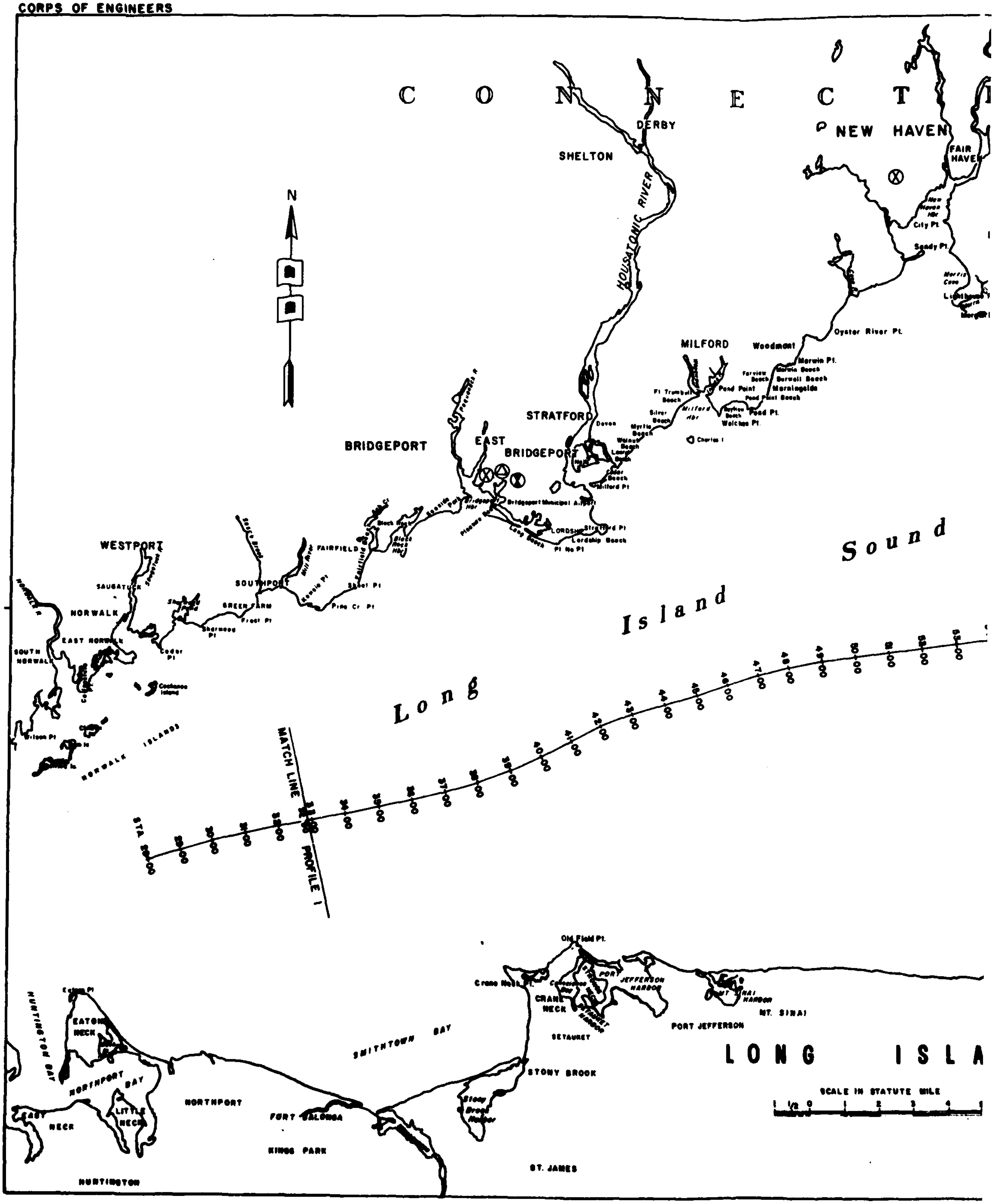


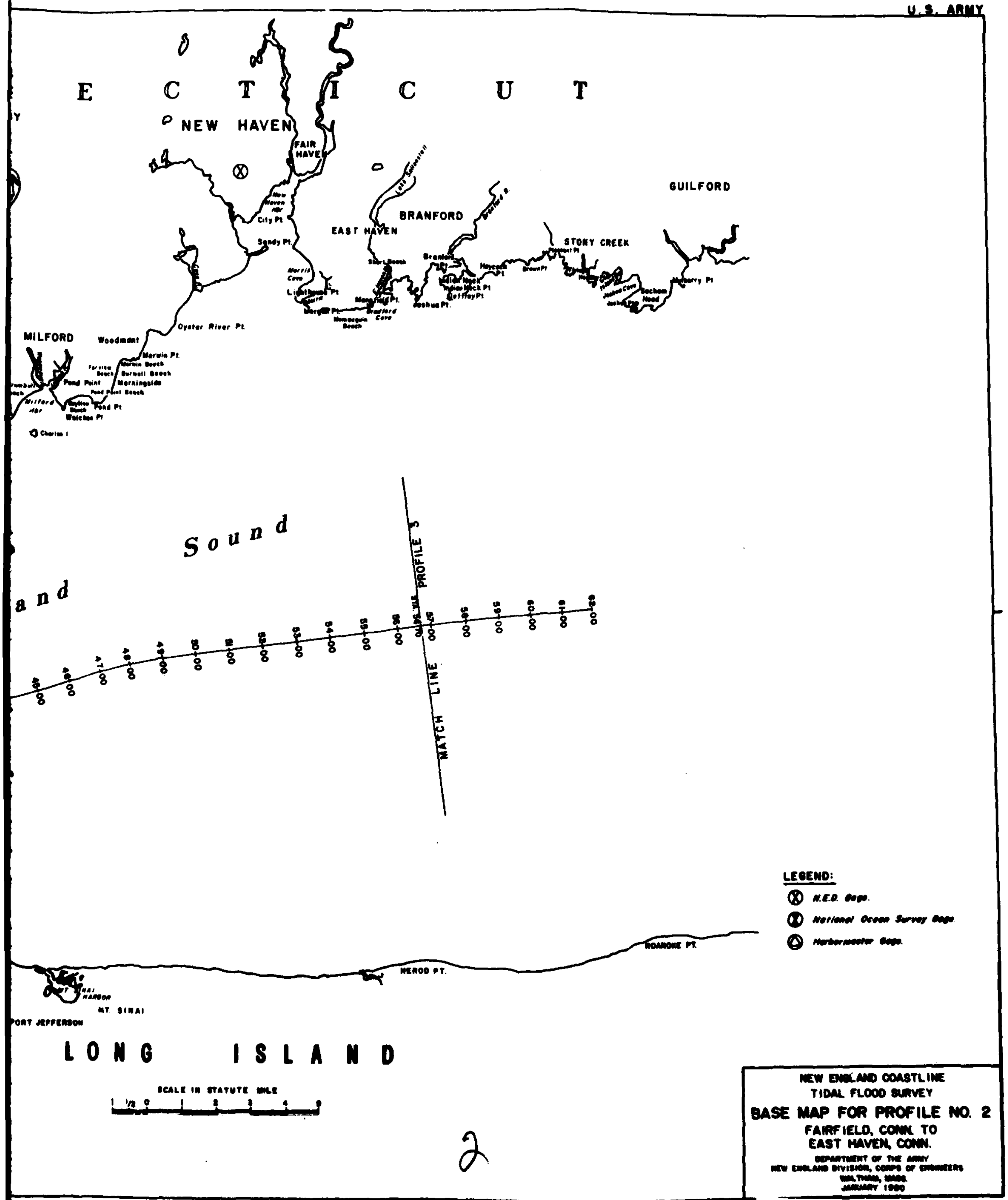

U. S. ARMY
CONNECTICUT
GREENWICH
STAMFORD
DARIEN
NORWALK
WESTPORT
FAIRFIELD
STAMFORD HARBOR
BYRAM HARBOR
GREAT CAPTAIN IS
BELLE HAVEN
FIELD POINT
GREENWICH HARBOR
GREENWICH CREEK
COS COB HARBOR
MIANUS RIVER
COS COB
GREENWICH POINT
GREENWICH COVE
OLD GREENWICH
RIPPOWAN RIVER
SHIPPAN POINT
WESTCOTT
HOLLY POND
DARIEN RIVER
LONG NECK POINT
SCOTT COVE
FIVE MILE RIVER
ROWAYTON
NOROTON POINT
WILSON POINT
HARBORVIEW
NORWALK RIVER
CALFPASTURE POINT
SAUGATUCK SHORES
SAUGATUCK RIVER
CEDAR POINT
COMPO BEACH
SHERWOOD POND
SHERWOOD POINT
ALVORD BEACH
FROST POINT
SASCO BROOK
MILL RIVER
KENSIE POINT
PINE CREEK POINT
FAIRFIELD BEACH
STANDARD PROJECT HURRICANE TIDAL FLOOD (3)
(STAMFORD OUTER HARBOR GREENWICH, CONN H.W. MARKS NO. 627-638, INCL.)
(STAMFORD HARBOR STAMFORD, CONN H.W. MARKS NO. 639-665 INCL.)
(SAUGATUCK RIVER H.W. MARKS NO. 712 & 721-738 INCL.)
STA. 32+90
MATCH LINE
PROFILE 2
ELEVATION IN FEET ABOVE N G V D
MEAN SPRING HIGH WATER (1)
VERTICAL DATUM (2)
MEAN LOW WATER (1)
LEGEND:
SEPTEMBER 21, 1938 HIGH WATER.
AUGUST 31, 1954 HIGH WATER.
675 NUMBER IDENTIFIES HIGH WATER MARK.
NOTES:
1 VARIES FROM YEAR TO YEAR VALUE GIVEN HERE BASED ON 19-YEAR SERIES OF TIDE OBSERVATIONS ENDING IN 1941, BY THE NATIONAL OCEAN SURVEY (FORMERLY U.S.C.&G.S.)
2 A FIXED REFERENCE ADOPTED AS A STANDARD GEODETIC DATUM FOR ELEVATIONS IN THE UNITED STATES OF AMERICA FORMERLY REFERRED TO AS MEAN SEA LEVEL (MSL) DATUM, BUT NOT TO BE CONFUSED WITH LOCAL MEAN SEA LEVEL
3 SPH TIDE LEVEL COMPUTED USING THE STAND OF SEA LEVEL OF 1941
LONG ISLAND SOUND
NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
TIDAL FLOOD PROFILE NO. 1
WILLETS POINT, N.Y. TO WESTPORT, CONN.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS
JANUARY 1980

2

PLATE 4-4

CORPS OF ENGINEERS



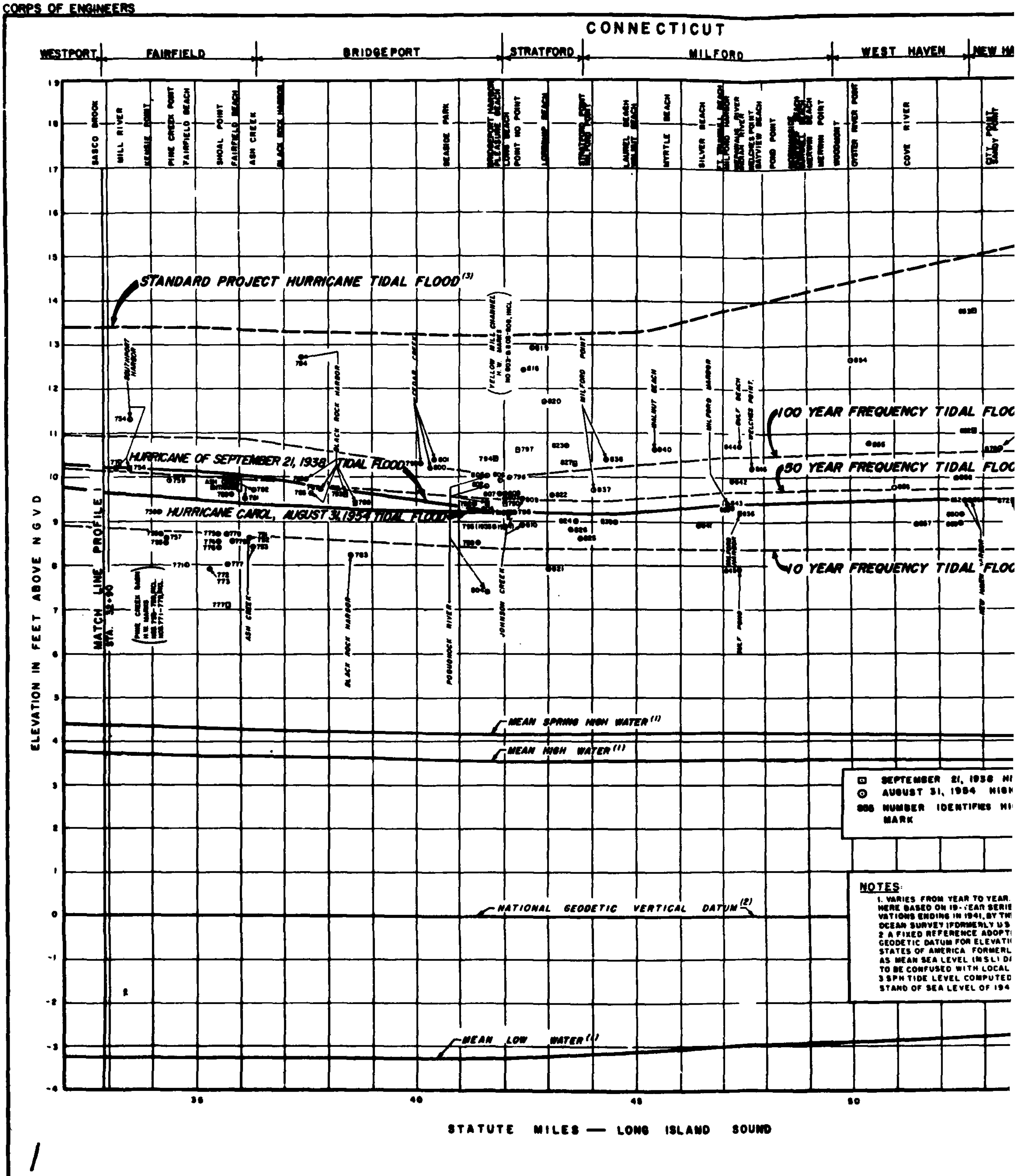


NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY
BASE MAP FOR PROFILE NO. 2
FAIRFIELD, CONN. TO
EAST HAVEN, CONN.
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.
JANUARY 1980

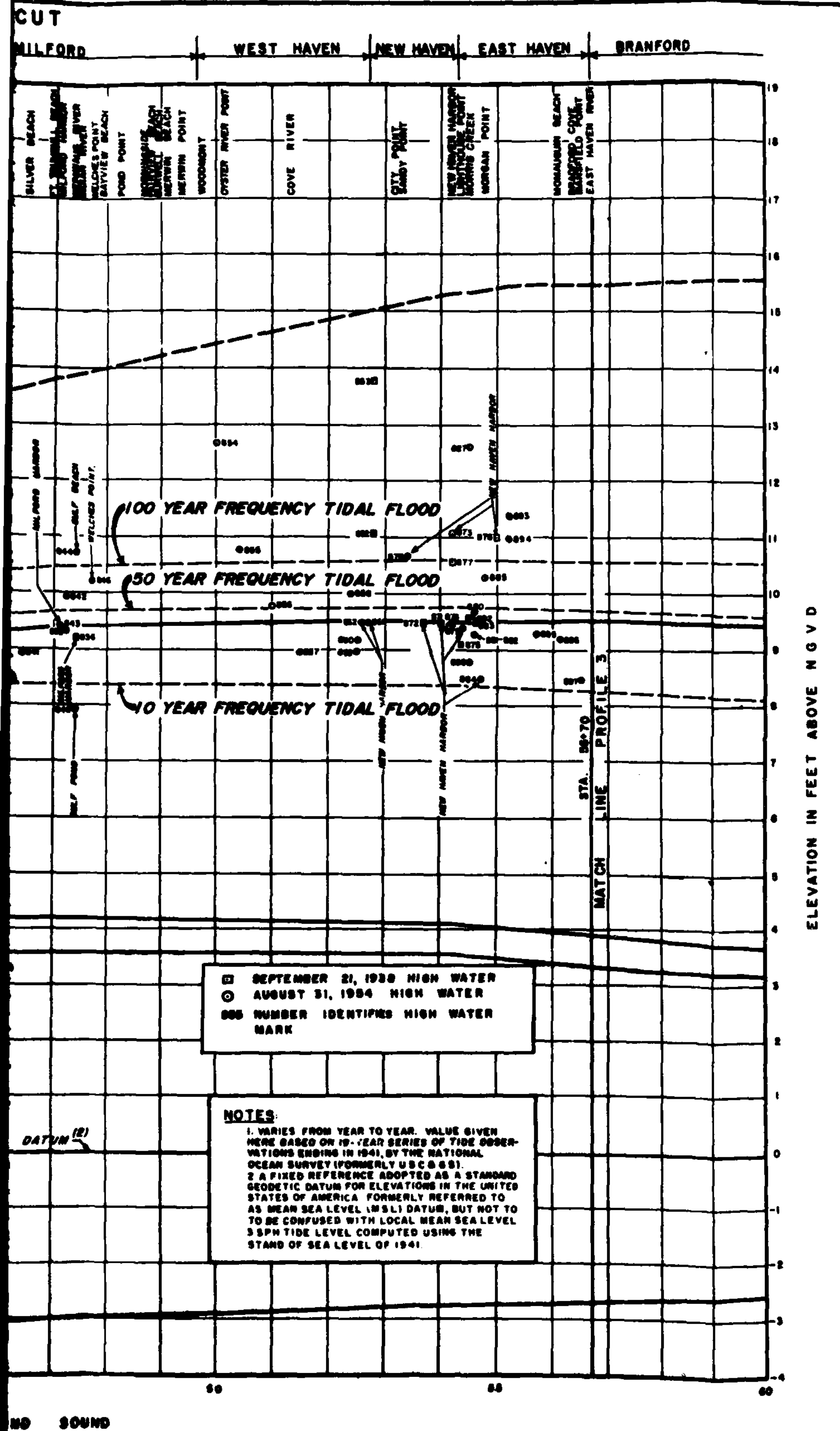
2

PLATE 4-5

CORPS OF ENGINEERS



U. S. ARMY



NEW ENGLAND COASTLINE
TIDAL FLOOD SURVEY

TIDAL FLOOD PROFILE NO. 2

FAIRFIELD, CONN., TO
EAST HAVEN, CONN.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS
JANUARY 1980

2

PLATE 4-6

COASTAL PROCESSES

GEOLOGY OF THE SITE AND SURROUNDING AREA

This appendix will discuss the geological setting of the study area with special emphasis on natural processes affecting the coastline. Included in the discussion will be a description of the geology of the site and surrounding area, a description of the existing coastline, the nature and effect of coastal processes impacting the study area, and a description of the changes the shoreline has undergone as a result of both natural forces and the effects of articical modifications such as groins and sand nourishment. The purpose of this section is to afford a better understanding of the results of past coastline modifications and the reasons, benefits, and limitations of proposed future modifications.

OVERVIEW

The embayed and irregular low lying coastline of Connecticut along Long Island Sound is a result of several processes and events occurring over a long span of geologic time. The bedrock of the region consists of a complex series of igneous metamorphic rocks. These crystalline basement rocks are overlain by glacially derived sands, gravels, silts, and clays of variable distribution and thicknesses. A portion of the unconsolidated sediments of glacial origin were reworked and redistributed by the sea as it advanced inland due to a slow rise in sea level. The several beaches, spits, bars, and marshes located along the shoreline were formed by the action of winds, waves, and currents, which transported and deposited the unconsolidated material. The deposits mapped in the vicinity of Sherwood Island State Park consist of rounded low hills of till, flat lying stratified deposits of sand and gravel of glaciofluvial origin, tidal marsh deposits, and recent beach and shore deposits of gravel and sand. The beaches originated as barrier beaches formed by an encroaching sea. Tidal marshes formed in a quiet environment behind the barrier beaches. The configuration of the beaches and the rest of the local coastline is constantly changing in response to the natural influence of wind, wave, tides and currents, as well as artifically imposed factors such as groins, revetments, jetties, and sand placement on beaches.

BEDROCK GEOLOGY

The geology of the Sherwood Point quadrangle has not been mapped in detail. Sufficient mapping has been accomplished on the adjacent quadrangles of Norwalk South and Bridgeport, however, to allow the geologic history and lithology of the area to be confidently inferred.

During most of geologic time the southwestern portion of Connecticut was subjected to repeated sequences of uplift, erosion, and deposition. The sediments formed in such a manner were subsequently intruded by molten rock material and folded, contorted, and metamorphosed by strong forces within the earth. This sequence of sedimentary and igneous rock formation accompanied by uplift, intense deformation, and metamorphsism was repeated several times during the Paleozoic era, which began 600 million years ago and ended about 200 million years ago. A sequence of faulting and minor igneous intrusions during the early part of the Mesozoic era signaled the end to this long peirod of intense geologic activity.

An extensive period of weathering and erosion followed the emplacement of the Paleozoic bedrock. The sediments formed at this time lithified as an irregular planar surface sloping southeasterly in the vicinity of Long Island Sound. Later uplift and subsequent erosion removed this rock material from the study area and the bedrock remaining in the area consisted of metamorphic gneisses and schists called the Hartland formation. Further weathering and erosion ensued and much of the rock which once occupied Long Island Sound was removed and the valley or depression now occupied by the Sound was formed. Further erosion of the coastal area was stopped by a worldwide climatic change which began about 2 million years ago and which initiated the flow of great masses of glacial ice over New England and much of the upper portion of North America. It is the results of this period of glaciation or "ice age" which has had the most profound and most immediate effect on the coastal geology of the Sherwood Island State Park area.

SURFICIAL GEOLOGY

The surficial geology of Sherwood Point, just as the bedrock geology has not been mapped other than on a reconnaissance level. Sufficient surficial mapping has been accomplished however, on nearby areas to allow confident inferences to be made of the nature and distribution of the sediments present and their geological history. Approximately 2 million years ago, at the beginning of the Pleistocene Epoch the earth's climate became cooler and the first in a series of ice sheet advances and retreats began. Ice, several thousand feet thick, spread slowly over much of North America including New England and reaching as far south as at least Long Island. Due to a rising of the earth's temperature, the ice began to melt and the margin of the ice sheet retreated to the north. This sequence of advance and retreat occurred at least 4 times with the last, called the Wisconsin Stage, beginning approximately 80 thousand years ago. Each stage of glaciation removed, changed and reworked the sediments and land forms produced by the preceding stage. Thus, only the land forms produced by Wisconsin glaciation are much in evidence today.

The effects of this glaciation were both erosional and depositional. As the Wisconsin ice sheet advanced over the land it eroded and sculptured the bedrock surface as it picked up, removed, and transported large amounts of rock material in the process. As rising temperatures brought on an end to the advance of Wisconsin Ice approximately 15 thousand years ago, the large volume of sedimentary material incorporated in the ice began to be deposited as the ice sheet melted and retreated. This sediment, lying on the rather flat gently sloping bedrock surface of the Hartland formation, was then reworked and shaped by winds and waves to form the coastal lands of the study area.

The Wisconsin ice sheet reached its maximum extent of southward movement approximately along the line which includes Long Island, Block Island, Martha's Vineyard, and Nantucket. The climate was such that the margin of the ice sheet remained at this equilibrium position for a few thousand years laying down large amounts of mixed rock material ranging in size from clay to boulders. This material, called till, formed ridge shaped terminal moraines which in turn formed the "backbones" of the islands just mentioned. With increased climatic warming, the ice sheet began to retreat from the area leaving a blanket of thinner deposits of both till and stratified drift on the land that it had covered. There is evidence to suggest that the retreating ice margin paused and a small recessional moraine was deposited just south of the study area forming what are today known as the Norwalk Islands. Following that relatively short pause, the ice margin continued to retreat and left irregular deposits of both till and stratified silts, sands, and gravels in the vicinity of the present day Sherwood Point. Sea level at the time of the deposition of these sediments had declined markedly (up to -400 feet) due to the formation of glacial ice. The shoreline at that time was therefore many miles seaward of its present day location.

Following the retreat of ice from the area the exposed glacial deposits were subjected to weathering and erosion prior to submergence from the rising sea. It is entirely possible that many of the south flowing streams in the area, such as the Norwalk and Saugatuck River and possibly smaller streams, such as Muddy Brook flowing into Sherwood Mill Pond and Green Farms Creek flowing to the inlet at Burial Beach, are remnants of larger streams which cut channels into the fresh glacial deposits. There is speculation that the tongues of mud found south of Compo Island may represent a channel filling of a postglacial stream. After an undetermined but relatively short period of time, the sea level rose in response to glacial melting and the shoreline advanced inland. The previously exposed irregular surface of glacial till and stratified drift became submerged and Long Island Sound was formed. The coastline of Sherwood Point and vicinity marks the present day limit of the advancing shoreline. Submergence is continuous however, and with time this shoreline will continue to advance inland.

The unconsolidated sediments in the study area consist of in-place and reworked till, glaciofluvial sands and gravels, and postglacial marshes and beach deposits. A sketch map of the surficial geology, as inferred from reconnaissance reports and adjacent quadrangle mapping, is seen in Plate 5-1.

The till deposits are unsorted, unstratified mixtures of boulders, gravel, sand, silt, and clay. These sediments were deposited directly from the melting, ice as opposed to being deposited from streams flowing from the melting ice. This till, called ground moraine in much of the literature of the area, mantles the irregular bedrock surface discontinuously and is found generally less than 20 feet thick in adjacent quadrangles. The deposits of ground moraine covering low bedrock hills make up the highest topographic features of the study area. The glaciofluvial deposits are stratified sands and gravels which have been deposited by melt water streams, either directly in contact with the ice or in front (south) of the retreating ice sheet as outwash deposits. These sediments are found commonly as aprons and probably overlying the lower elevations of the hills of ground moraine.

The topography and sediment distribution of the area immediately following deglaciation is not known, but it was probably characterized by low hills of till with stratified sands and gravels of glaciofluvial origin in the valleys and lowlands between the hills. As sea level rose and the shoreline progressed inland some of the unconsolidated sediments were reworked and redistributed by winds, waves, and currents. This reworked material was then deposited as a relatively thin covering on the glacial sediments. In some places, however, the postglacial gravel sands and muds have been measured at up to 50 feet thick and more. Since the preglacial bedrock surface slopes in an irregular fashion to the south, the glacial and postglacial sediments in Long Island Sound become progressively thicker towards the south.

Sea level has been rising at varying rates in the area since deglaciation occurred approximately 15 thousand years ago. The present rate of sea level rise has been estimated by the committee on Tidal Hydraulics, U.S. Army, Corps of Engineers, at approximately one quarter of an inch per year. As the sea encroached over the land the sediments were redistributed with a finer sized material being deposited in quiet low energy areas such as deeper water offshore environments or in nearshore bays and inlets protected by barrier beaches of some kind. The coarser materials, sands and gravels, are deposited in areas characterized by higher energy environments such as the beaches and the area immediately offshore of the beaches.

Mixtures of sand and gravel or sand aud mud are the predominant sediment types in the study area and offshore area. The generalized distribution is as follows: gravel or a mixture of sand and gravel on the beach, sand on the nearshore area, and deposits of sand and mud or sand and gravel further offshore. Mud occurs in local deeper areas offshore and in the marsh areas.

The evolution of the present coastline (excluding the structural and nonstructural modifications recently placed in the area) can be reconstructed from a study of the existing topography and shoreline. Although conjectural, the sequence of events as here described is sufficiently accurate in principle to serve as an aid in the understanding of the coastal geology of the Sherwood Island State Park area. A line of discontinuous barrier beaches situated offshore from the present beach characterized the area several hundreds of years ago. Between this line of barrier beaches and the mainland (now approximately marked by the east-west line of the Connecticut Turnpike) there was a shallow lagoon inhabitated by several islands rising as rounded hills from the water. Streams such as Muddy Brook and Green Farms Creek, flowed into this protected water. Tidal currents, overwash and general wave movement transported fine material into the lagoon which settled out in this low energy quiet environment. This accumulation of mud and silt was somewhat augmented by deposits of silt and mud from streams flowing from the main land into the lagoon. With time, sufficient thicknesses of mud accumulated to support vegetation and a tidal marsh began to form. Wave action and the effect of rising sea level moved the barrier beaches inland and the marsh land continued to develop and form. As the migrating beaches encroached upon an island in the lagoon, the inland progress of the beach at that point slowed markedly relative to those portions of the beach on either side of the island. This action formed shallow headlands, such as Sherwood point. Marsh deposits continued to form in back of the barrier beaches until most of the lagoon was filled with peat and other marsh deposits. The location of low hills of glacial till present in the area, such as Compo Hill and the unnamed low hill on which the road in Sherwood Island State Park are located, influenced the position of the linear present day beach. The other main influence on the shape of the barrier beach was longshore transport which formed spits and elongated the beach area. These processes continued and shaped the coastline that existed prior to man's modification of the area. Simply stated, the study area coastline was characterized by a barrier beach interrupted by occasional stream channels and shaped into cusps with low hills consisting predominately of glacial till with some bedrock control forming the points. Longshore transport also contributed to the shape of the beach by moving sand and forming spits.

PRESENT COASTLINE

OVERVIEW

This section will describe the physical features of the coastline as it exists today. Beach width, sediment composition, and slopes of beach

profiles are displayed in Table 5-1. The hydrology of the area including surface streams and Sherwood Mill Pond will be described. Special reference will be made to the effects of tidal changes on the Mill Pond.

BEACH DESCRIPTION

For purposes of this report the beach in the study area is divided into the following segments: East Beach, Sherwood Point, West Beach (east and west parts), and Compo Cove Beach. The description of each segment will include the width of the beach above mean high water, the width between mean low water and mean high water, and the composition of the beach material. Additionally the slope of each beach will be given in three parts extending seaward; beach face slope, near inshore shelf, and inshore. The length of profile extends 900 feet seaward from the baseline. The length of each segment of beach will also be specified. The data for each of these parameters, for the years 1949, 1974, and 1980, is shown in Table 5-1.

HYDROLOGY

SURFACE STREAMS

Two tidal streams, Muddy Brook and Green Farm Creek, are present in the study area. Both streams drain relatively small inland lowland areas The sediment discharge of both is insignificant except in times of flood. Muddy Brook drains into Sherwood Mill Pond and Green Farm Creek drains into Long Island Sound at the site of the two training walls at the east end of East Beach.

SHERWOOD MILL POND

The Mill Pond was created in the 1800's by the damming up of Muddy Brook which extends about four miles in a northerly direction. Two tidal gates control the flow with one of the gates being cemented closed in the early 1960's. Photo 16 shows the tidal gates.

The pond bottom is generally flat, suggesting that prior to the damming of Muddy Brook, the area now occupied by the pond was part of the low lying marsh system found in much of the area landward of the barrier beach. With reference to mean low water the elevation of the pond bottom is approximately +5 feet, and in the deeper channel area the elevation drops to +1 foot, and in the shoal areas near the outlet the elevations range from +5 to +6 feet.

A comparison of present and past elevations (Corps of Engineers, 1949) suggests that the southwestern portion of the pond has filled almost 1 foot with sediment brought in from Compo Cove and from eutrophic deposition. Sand deposits in the southern section of the pond, sampled in 1979, are similar to those found in the lower foreshore and nearshore areas of the beaches in the study area. A sample deemed representative of the northern and western portions of the pond is composed primarily of silt and clay, indicative of either the prepond marsh stratigraphy or of more recent eutrophication in the pond.

The pond serves as a basin for the drainage of Muddy Brook. The pond is connected to the sea through the tidal gates opening to Compo Cove and through Burial Creek (called Mill Creek on the U.S. Geological Survey topographic map of the area). A tidal flood cycle is followed in which water enters the mill pond from Long Island Sound once the tide of the Sound rises above the level of the pond. This flood continues until the ebb tide brings the level of the Sound below that of the pond. At this point the pond discharges into the Sound until a rising tide once again reaches and exceeds the level in the pond and the cycle starts anew. The majority of the exchange of water takes place through the outlet to Compo Cove. Field measurements have suggested that approximately 88 percent of the pond tidal prism entering the mill pond is exchanged (or "new") water from Long Island Sound. It has been estimated that there is a 68 percent flushing rate at spring tide, 26 percent flushing rate at mean tide, and a very low flushing rate at neap tide. Drainage from Muddy Brook is only significant after periods of heavy rainfall.

COASTAL PROCESSES IMPACTING THE STUDY AREA

OVERVIEW

The forces of winds, waves, tides, and currents are the natural elements working to modify and reshape the configuration of the coastline at Sherwood Island State Park. This section will describe each of these elements as they occur in the vicinity of the study area. The effects of these forces on the erosion, deposition, and general sediment transport in the study area will also be discussed.

WINDS

Waves affecting beach erosion and sand movement at Sherwood Island are primarily caused by wind. Wind waves are influenced by the following

three factors: wind velocity, fetch (length of open water over which wind blows), and wind duration. Generally speaking the longer the fetch, the stronger the wind; and the longer the wind blows the larger are the resultant waves.

Because of the location of Long Island to the south and the mainland to the west, Sherwood Island is affected by a relatively long fetch only from an easterly direction. The fetch distance-wind direction relationship for the study area is summarized below.

Direction	Fetch In Miles
East	45
Southeast	20
South	10
Southwest	20

An index of wave effectiveness with respect to beach erosion can be formulated by multiplying the fetch distance by percent of total wind activity (Ellis-1960). The wind directions and percentages of occurrence for the onshore winds in the Bridgeport area can be used to calculate the wind effective indices for Sherwood Island. This information is presented below.

Compass Direction	Percentage of Total Onshore Wind (From Tidal Hydrology Appendix 4)	Fetch In Miles	Relative Effective Wind Index
East	17	45	765
Southeast	12	20	246
South	22	10	220
Southwest	31	20	620

Further analysis of wind direction, discussed in detail in the Tidal Hydrology Section of Appendix 4, shows that the principal wind direction for slower and intermediate speed winds (less than or equal to 25 miles per hour(mph)) is from the southwest to west-southwest. The principal wind direction for higher windspeeds (over 25 mph) are from the east. The principal overall direction of onshore winds is from the southwest. The resultant wind direction, a vector quantity computed using the product of wind speed and direction, is from the south-southwest with an average resultant speed of 6.9 mph. The greatest percentage of windspeeds is in the 10-15 mph range.

The above analysis shows quite clearly that the major storm winds with the greatest erosion effective index are from the east. Although relatively infrequent, the evidence strongly suggests that easterly winds are the dominant sediment transport force in the area causing longshore movement of sand in a westerly direction. The winds from the south and southwest, although prevailing, are less effective as erosional forces due to considerations of fetch distance and shoreline configuration.

The principal effect of wind on the study area is the formation of waves and currents which move and redistribute the sand and by doing so contribute to the reshaping of the beach. Although the preceding discussion has been limited to an analysis of the onshore wind, a study of all wind in the area shows the overall prevailing wind direction to be offshore. Therefore, some offshore movement of fines due to the wind is to be expected, but there is no data to suggest whether or not the movement is significant. Storm winds are also responsible for storm surges. In that the effect of storm surges is directly related to the tide levels, any discussion of storm surges will be included in the section on tides.

WAVES

The size of waves is a function of the fetch distance, water depth, and magnitude and duration of sustained wind velocity. Sherwood Island State Park is located so that swells of significant height do not encroach upon the study area. The waves are almost exclusively generated by local winds and are normally small. Studies in 1959 reported that waves at Burial Hill Beach on the eastern side of the study averaged 0.78 feet in height and 2.85 seconds in period.

Use of deepwater forecasting curves from Volume 1 of the 1977 edition of the Shore Protection Manual furnished the following wave heights and period data for various combinations of wind velocity and fetch characteristics of the Sherwood Island area.

Fetch in Nautical Miles	Wind Velocity in MPH	Wave Period in Seconds	Wave Height in Feet
50	22	4.8	4.7
	28	5.5	6.3
	35	6.3	8.4
28	22	4.3	3.8
	28	4.9	5.0
	35	5.6	6.6

(These figures assume a steady wind of between 4 to 8 hours duration.)

These figures support the inferences of the previous paragraph on wind which, quantifying fetch-wind velocity relationships, suggest that the easterly winds although infrequent are the dominant force in a sediment transport in the area, and thus a generally westerly sediment movement is to be expected. The southerly winds are much more constant, however, and will certainly also have a significant effect on sand movement in the area. These factors will be discussed further in the Section titled, "Shoreline Changes."

The effect and role of waves in erosion and sand movement on the coast have been studied. One of the areas of investigation has been the construction of wave orthogonals from different directions and for different wave periods. These orthogonal studies have suggested that the waves approaching from the east produce the strongest westerly littoral movement. The effect of this easterly movement is most apparent along West Beach. There is some littoral movement, to a lesser extent, along East Beach. The influence of waves approaching from the southeast is similar but less intense than waves approaching from the east.

Waves approaching from the south encroach on both East Beach and West Beach in an almost shore normal fashion. There is then little drift generated by waves approaching from the south on either East or West Beaches. Wave orthogonals drawn for waves approaching from the southwest show a slight tendency for easterly drift on East Beach. These same orthogonals suggest that there is a slight divergence of littoral drift on West Beach with the eastern half of West Beach being subjected to a slight easterly drift and the western part of West Beach being subjected a slight westerly drift. The slight easterly drift suggested by the orthogonals at the eastern part of West Beach may very well be partially responsible for the deposition of the bulge of sand found quite prominently on the eastern part of West Beach.

In summary it is apparent that westward drift affects all beaches of Sherwood State Park when they are under the influence of easterly generated waves, especially storm waves. The quieter but more prevailing winds from the south and southwest tend to either have a very minor easterly drift effect on beaches or, in the case of waves approaching from the southwest, a slight westerly drift. On East Beach the westerly drift generated by the infrequent easterly waves is probably balanced off by slight easterly drift generated by the prevailing south-southwesterly and southwesterly winds. The erosion of West Beach is characterized by predominantly westward movement generated by easterly waves and, in the west part, by waves generating from the southwest.

The wave refraction analysis also indicates various types of substantial movements in the immediate vicinity of Sherwood Point. Analysis of waves approaching from the south indicate a strong convergence at the point with a rapid erosion and offshore movement, and a strong alongshore movement for a short distance to the east and west of the point.

TIDES

The movement of water due to tidal forces results in some transport of beach material within the study area. Although relatively minor sand movement occurs on broad beach faces as a result of tidal motion, more significant sand transport is seen in the vicinity of inlets. The tidal range is significant when considering the erosion and sand transport due to storms. Storms surges coinciding with high tides usually result in significantly more beach erosion than those occurring at low tide. A more detailed list of still water tidal levels may be found in the Engineering Appendix.

The mean tidal range in the study area is 7 feet with the spring and neap tidal ranges being 8 feet and 5.8 feet, respectively. These figures were supplied from 1980 tide tables.

Storm tidal surges with elevations of 3 feet or more above mean high water have a reoccurrence frequency of almost once per year. Stronger storms that produce higher tidal surges usually follow generally northerly tracts, which bring them over the eastern entrance to Long Island Sound. They are usually slow moving and thus allow storm surges to last through one or more complete tidal cycles. The storm surges resulting from the storms (hurricane and strong northeasters) become progressively higher from east to west.

The magnitude and frequency of occurrence of tidal surges associated with large storms affecting the study area are tabulated in Table 5-2

The sediment transport associated with storm tidal surges is usually significant and under most circumstances results in erosion of the beach. One estimate of erosion to depth of 4 feet within the surf zone near normal high tide level was projected for a storm wave of 10.5 feet above mean low water (7.6 feet NGVD) (Corps of Engineers, 1974). This amount of erosion should be viewed as a rather common occurrence since the wave of 10.5 feet above mean low water (7.6 feet NGVD) is estimated to occur approximately once every two years. Erosion rates from storm surges of lower frequency events, especially at high tide, would be correspondingly higher. It should be mentioned that although storm tidal surges usually cause beach erosion, there have been storm events that have caused beaches to accrete. No data is available for the study area regarding the effect of strong tidal surge heights on specific quantities of sediment transport.

Tidal rise and fall of the water surface results in tidal currents of water moving on and offshore. This movement is significant generally with respect to inlet areas and specific to the study area because of the inlets at Burial Hill Creek and Sherwood Mill Pond. A Lagrangian current survey was performed in April 1979 (FGA, 1980) for flood tidal currents in the vicinity of Burial Hill Creek and for about 1/2 mile offshore of the western part of the study area. From just east of Sherwood Point to a point directly offshore from Compo Cove. A survey of ebb tidal currents was performed in nearshore water, along the line from the middle of East Beach to Compo Cove.

The flood tidal currents measured off Burial Hill Creek were relatively weak, with speeds of 0.1 to 0.4 feet per second. The current direction was shoreward reflecting the inflow to the creek. The direction of the flood current for 1,000 feet on either side of the creek entrance was also shore normal. Although no ebb tidal currents were measured in this area, the stability of the beach suggests that the current motion occurring as the tide ebbs might also be shore normal. Such a condition would not contribute to any significant longshore transport. Sand movement would be in equilibrium and confined to a rather steady state of offshore and onshore motion.

A strong westward moving flood tide current approximately 2,000 feet off of West Beach was measured. The velocity of the current ranged from 0.9 to 1.0 feet per second offshore from Sherwood Point and diminished to the west. Closer inshore, a weaker current with velocities averaging from 0.1 to 0.2 feet per second was observed trending northeast to east northeast. This current most likely represents an eddy forming in the lee of the point and possibly indicates the presence of eddys of other currents in the area. The existence of this current tends to support the contention made in the section on waves that eddy currents in the lee of the point from waves generated by easterly winds may be largely responsible for the deposition of the lobe or bulge of sands referred to previously.

CURRENTS

Observations have shown that the currents which have significant impact on beach morphology in the study area are predominantly wave induced longshore currents. Tidal currents most probably transport some sand but either the motion is off and onshore or the current is too weak to be significant (see section on tidal currents immediately preceeding this section). The one exception to this condition is at the mouth of Sherwood Mill Pond. Evidence there suggests that flood tidal currents are bringing material into the pond area near the tidal gates and producing shoaling from a flood tide delta.

The dominant currents are wind and wave induced. Orthogonal plots for waves advancing from the east to southwest directions have been diagrammed and are presented on Plates 1-6 through 1-9. The plots show quite clearly that waves coming from the south and southwest strike both East and West Beaches in a near beach normal fashion. Waves approaching from the southwest effect some slight component of littoral drift. There is a slight easterly component of drift on East Beach. On West Beach, there is a slight easterly drift component on the east side and a slight westerly drift component on the west side.

Waves approaching from the east and southeast directions approach the shorefront at oblique angles which range from acute at West Beach and Compo Cove Beach to more normal but still somewhat oblique at East Beach. The more easterly the wave direction, the more oblique the angle on both beaches, longshore current moving parallel to the beach front in the same general direction as the incoming wave. These currents move sand which was put into prior movement (bedload or suspension) by the breaking waves at the surf zone. The result is a net sediment transport along the shore in the same direction as the longshore current.

As was previously discussed in another section, the wind directions affecting the study area are limited to the east through southwest. The prevailing winds are from the south and southwest and the dominant winds are from the east.

The bulk of shoreline sediment movement along the study area coast occurs during the infrequent wind generated storm waves rather than during the normal fair weather conditions. It is apparent from a study of wave directions that a dominant westerly longshore transport of sand occurs along West Beach (and Compo Cove Beach) and only a slight westerly component at East Beach. This slight westerly component may very well be neutralized by the slight easterly drift resulting from waves coming from the southwest direction. Superimposed on this general picture is the eddy effect on the west side of the Sherwood Point, which may produce the lobe of sand observed there and the effects of any structures built in the area such as groins or jetties. These will be discussed later in the report.

SHORELINE CHANGES

OVERVIEW

As a result of the various coastal processes described earlier acting on the shoreline, the configuration of the coastline and the shape of the beaches are constantly changing. Sand movement is continual whether it be

shore normal in the surf zone, alongshore littoral drift, or movement further offshore. In addition to the natural processes occurring, the several modifications to the coastal system such as sand and nourishment, revetments, groins, and small jetties all result in shoreline changes. The changes in beach width, depth profiles, and quantitative amounts of sand moved will be discussed in this section.

EROSION RATE

In describing the changes in the study area the beaches will be subdivided into the same three areas as previously discussed: East Beach, Sherwood Point, and West Beach. Shoreline configurations surveys were made of the beaches in 1955, 1957 (following construction), 1971, and 1980. These surveys have been used to document the shoreline changes over the past 25 years and to make estimates of rates of beach erosion. The information is presented in Table 5-3.

VOLUME TRANSPORT

EAST BEACH

Immediately following the sand nourishment program of 1957, East Beach improved with substantial accretion of sand. Between 1962 and 1971 there was a small amount of erosion of sand above the high waterline and from 1971 to 1979 there was approximately the same amount of accretion. There is then net accretion of sand on East Beach following the sand nourishment program of 1957. East Beach has suffered some net erosion on its east end, since 1957, (in the lee of the training wall) and west end (as it merges with the point), but the overall result has been net accretion of sand above the mean high water level. Further, the sand appears to be in a state of dynamic equilibrium with minor losses due to erosion being balanced by additions of approximately the same magnitude.

The quantative amounts of this sand volume transport, as gained from profiles of 1957, 1962, 1971, and 1979 are tabulated below.

1957-62	+22.7 thousand cubic yards
1962-71	-3.9 thousand cubic yards
1971-1979	+3.3 thousand cubic yards
NET	+22.1 thousand cubic yards

SHERWOOD POINT

The point has generally undergone rather rapid erosion and only structural modification such as the present revetment has allowed the point to maintain its present shape. Volumetric change of the "beach" (mostly rock) above mean high water as gained from 1957, 1962, 1971, and 1979 surveys are:

1957-1962	- 11.1 thousand cubic yards
1962-1971	- 6.5 thousand cubic yards
1971-1979	+ 1.4 thousand cubic yards (result of 1976 revetment)

WEST BEACH

Following the 1957 program of sand nourishment, West Beach, as did all the segments of beach front in the study area, underwent marked accretion. Since that time, however, the West Beach area has suffered substantial erosion. A section of the beach, extending for approximately 800 feet immediately east of the existing groin strucutre, has continued to accrete as a result of westward moving littoral drift being trapped by the structure. The remainder of West Beach, extending approximately 1,000 feet to just west of Sherwood Point, has undergone erosion, at places severe, sufficient to account for a net overall erosion figure for the entire West Beach.

The quantitative values for sand volume transport on West Beach were gained from surveys in 1957, 1962, 1971, and 1980. For purposes of this discussion, transport figures for the "East Segment" of West Beach were taken between profiles 14-15, and 15-16. The "West Segment" of West Beach comprises profiles 16-17, 17-18, and 18-19. The sand volume transport for West Beach is displayed below.

Date	Above MHW	MHW to MLW	Below MLW	NET
	(Volume changes in cubic yards X1000)			
West Beach 1957-1962	+22.2	+1.8	+21.0	+45.0
West Beach 1962-1971	-0.8	-14.0	-9.0	-31.0
1971-80				
East Segment	-8.7	-3.24	-4.3	-16.2
West Segment	+1.6	+0.08	+2.7	+ 4.3
TOTAL WEST BEACH	-7.1	-3.2	-1.6	-11.9
West Beach 1957-80	+7.1	-15.4	+10.4	+2.1

When comparing the 1957-80 changes with those from 1957-1962, it is readily apparent that the entire West Beach is undergoing significant losses due to erosion. Between 1962 and 1980 there was a loss of 15,000 cubic yards above mean high water, 17,000 cubic yards between MHW and MLW and 11,000 cubic yards below MLW. All that remains from the initial accretion following sand nourishment in 1957 in the zone below MLW is a thin covering of sand approxmately 3-1/2" thick.

OFFSHORE CHANGES

Bathymetric Profiles for 1835, 1883, 1916, 1933, 1971, and 1980 in the vicinity of the study area are used to compile information regarding offshore changes. Data for the 6', 12', and 18' depth contours (5, 10, and 15 feet for 1979) are displayed in tabular form, in Table 5-4, for the three previously defined segments of the beach.

EFFECTS OF STRUCTURAL MODIFICATIONS

The shoreline changes discussed in detail above are the result of a general pattern of the forces of wind and wave actions on the particular configuration of the segments of the coastline of Sherwood Island State Park. East Beach is oriented normal to the prevailing wind and, thus, is not affected much by waves from that direction. The infrequent occurrence of high energy waves from the east does cause sediment transport to the west but this, ever since the revetment of Sherwood Point, has been offset or balanced by the lower in magnitude but higher frequency southwesterly winds. In short, East Beach is now stable, West Beach is in an unstable

configuration and longshore transport occurs under conditions of both the dominant and prevailing winds. The almost continuous sediment movement is attempting to realign the beach to a more stable configuration similar to the orientation of East Beach. This realignment is helped significantly by the sand trapping capacity of the groin at the west end of West Beach. In addition to the deposition and realignment occurring at its west end, West Beach is also undergoing limited depostion at its east end as the result of eddys forming in the lee of the point.

This pattern is present today and is the result primarily of natural forces. Modifications have been made to the coastline over the past 25 years and they have impacted upon development of the present day coastline and the current pattern of erosion and deposition. The several modifications to the beach will be discussed along with the effect of these modifications on the shoreline.

Sand Nourishment - 1957 - Sand was applied to East and West Beaches in 1957 so as to widen the beaches to 150 feet along 6,000 feet of shoreline. In addition sand was stockpiled by the placement of sand to an additional 100 feet for 1,000 feet east and west of the point. The general westward sediment transport characteristic of the study area rather quickly removed significant amounts of this nourishment sand. Other than temporarily slowing the normal rate of erosion of the park's shoreline, the sand nourishment modification had little effect on the area. The nourishment did, however, significantly contribute to the shoaling of Compo Cove and most probably, through flood tidal deltas, to the shoaling of the Sherwood Mill Pond near the tide gates.

Western Groin - 1957 - The groin constructed at the west border of the park in 1957 was 500 feet long at an elevation of 12 feet, (11 feet above MLW). Although this structure did trap some sand, it was low enough to allow sand to be transported past it through the mechanism of wind movement and wave overtopping. It was thus a part of the equilibrium process.

West Groin Modification - 1976 - The landward portion of the groin was raised to an elevation of 21 feet in 1976. The most serious effect of this modification was the cessation of westerly sediment transport. The groin was high enough to stop all the sand from moving westward along West Beach and onto the small portion of State beach and Compo Mill Beach. With the sand supply to this area cut off, erosion of the beach began. By 1977 the eastern side of this area had experienced "severe erosion" and the Connecticut Department of Environmental Protection placed large stones and boulders in front of the houses of the Compo Mill Beach residents in order to prevent damage to the structures.

Point Revetment - 1976 - In 1976 Sherwood Point was extended 250 feet and armored. As a result, sand which had been drifting, although in relatively minor amounts, westward from East Beach was constrained to remain on East Beach, thus stabilizng East Beach. The east end of West

Beach lost more sand between 1971-1979 than betweewn 1957-1962 and it is entirely possible that the construction of the revetment contributed to this increased rate of erosion.

A second effect of the revetment was the stabilization of Sherwood Point. Prior to 1971 the rate of erosion at the point was 15 feet/year and since 1976 the point has been stable.

A third possible effect of the revetment was an increase in the eddy effect of westward moving waves and thus increasing deposition in the lee of the point. The bulge, prominent on the east end of West Beach was not present in the 1971 MHW survey but is noticeable in the 1980 survey.

PROPOSED ALTERNATIVES

OVERVIEW

When veiwed from the perspective of geologic time, the dominant trends in shoreline change that have been occurring for thousands of years will continue. The shoreline will slowly advance inland and the dominant sediment transport will continue from east to west. Certain carefully considered shoreline modifications can, however, allow us to derive maximum benefits from the present day coastline and can slow the rate of natural changes to allow a long-term recreational use of the area. This section will discuss the impact of the proposed alternatives on the study area. The impacts predicted are based upon the relationship between the given alternative and the patterns of shoreline processes discussed previously.

IMPACTS OF PROPOSED ALTERNATIVES ON THE COASTLINE OF THE STUDY AREA

NO ACTION

Under the no action plan, the study area would continue to deteriorate resulting in the loss of beach space and damage to the recreational area. Since East Beach is presently in a stable condition, erosion there would proceed very slowly and would most likely not become significant for many years. Sherwood Point would continue to suffer damage to the rock revetment which, when breached, would result in renewed rapid erosion of the area near the park headquarters and pavillion. West Beach would undergo rapid and severe erosion at its east end. The pre-1957 condition of this beach segment was described as boulders and cobbles above high water and shingle and marsh below high water. This portion of the beach will certainly return to this condition if no action is taken. The west portion of West Beach will accrete until the groin there has filled to maximum capacity. Once that maximum capcity is reached, any sand remaining on West Beach (other than that trapped by the groin) will be transported west of the groin by an as yet undetermined process of offshore movement.

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WEST BEACH, WESTPORT, CONNECTICUT, SHERWOOD ISLAND STATE PARK, --ETC(U)
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PROPOSED PLANS

Four plans of modification were selected for comparison. Each of the plans will be described along with a discussion of the impacts of various elements of each plan on the shoreline of the study area.

Plan 1 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline extending from the east limit of study at Sherwood Point to the west limit of study at the existing Federal groin structure.

This beach nourishment plan would have the effect of replacing sand lost since the last major nourishment, which occurred in 1957, and creating a safe and aesthetically pleasing beach. Unless other modifications were constructed or a program of sand renourishment was undertaken, the beach would quickly lose most of this sand in a manner similar to that which occurred following the 1957 nourishment.

Plan 2 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, and lowering the landward end of the existing Federal groin structure.

One new element is included in this plan; lowering of the landward end of the existing Federal groin structure. This section would allow sand transport over the groin by the action of wave overtopping. Some of the sand now held by the present higher structure would be lost. However, the beach on the up-drift side of the groin would rather quickly realign itself to be more in natural equilibrium with the existing wind and wave forces, and thus should become stable without futher significant loss of sand, providing a source remained further up-drift. In short, the lower groin would allow some sand transport to the west out of the study area, but this movement is more in agreement with the natural processes acting on the area, and as long as a sand nourishment program was continued, the beach should remain stable after an initial readjustment.

Plan 3 - This plan consists of widening the existing beach by the direct placement of suitable sandfill along approximately 1,800 feet of shoreline within the project limits, lowering the landward end of the existing Federal groin structure, and constructing a low-profile groin structure located between Sherwood Point and the Federal groin structure.

The construction of a low-profile groin structure located between Sherwood Point and the existing Federal groin structure is the one new element of this plan. The new groin will be constructed so that it is parallel to the existing groin and thus necessarily oblique to the shoreline. It is anticipated that the proposed groin will trap sufficient sand moving westward from the vicinity of the point to form a stable beach between the groin and the "bulge" now prominently seen just west of

Sherwood Point. The configuration of sand now trapped by the existing groin suggests strongly that the shoreline of the new beach formed east of the proposed groin will approach an ENE-WSW bearing more similar to East Beach than the NW-SE trend of the existing shoreline. The beach formed between the two groins will be similar to the beach now existing on the updrift side of the existing groin. The low profile of the proposed groin should allow sufficient sand to move over it during wave ovetopping to nourish and balance the sand leaving this beach through wave overtopping at the west (existing) groin. It is anticipated, therefore, that the beach now present updrift of the existing west groin will not be substantially altered from its present state. There may be some accretion at its east end which will align its shoreface slightly more to the ENE-WSW. When both segments of the beach finish adjusting to the construction of the new groin, they both will be aligned more parallel to the present East Beach than they are at present. Since this groin will be low profile, overtopping and sand transport will occur. This groin will be part of the dyanmic equilibrium sand transport process in the study area rather than a total barrier to it.

Plan 4 - This plan consists of the formulation and implemention of shore management planning guidelines. Also included is the restoration of the backshore dune at the western portion of West Beach, and grass planting and controlling access to maintain and preserve the dune. This plan will certainly have a favorable, positive impact on the beach and backshore facilities. The careful management of this area will result in less cultural erosion and better protection of the shoreline. The restoration of the dune will serve to conserve the sand in the area and may serve as a protective barrier in case of extraordinarily large storm waves.

This plan would lose much of its effectiveness if it were considered as the only plan of improvement in the area. It is best viewed as a plan to complement and serve as support for other alternatives proposed in this report.

SUMMARY

Several geologic and coastal processes are of special engineering significance to the study area. A description and discussion of these factors will serve as a summary to this appendix.

GEOLOGY OF THE AREA

Sherwood Island State Park and adjacent areas are composed of unconsolidated silts, sands and gravels of glacial origin lying over an irregular bedrock surface. With local exceptions, the bedrock exerts

little control on the topography of the land or shape of the coastline. The coastal area is subject to rather rapid erosion due to the unconsolidated nature of the sediments which compose it. Without the present and considered beach improvement modifications, there is no doubt that the entire coastline of the study area and adjacent areas would suffer severe erosion.

SHORELINE CONFIGURATION

East Beach is oriented such that most waves approach it in a near-shore normal direction. Only the more infrequent storm waves approaching from the east, and the less intense but more common waves from the south-west, strike East Beach at a sufficient angle to cause some longshore transport. The directions of longhsore transport in each case are opposing, however, and tend to cancel each other out. This is especially true since the construction of the extension of the revetment at Sherwood Point which blocks any sand from moving to the western part of the area. East Beach is considered stable within the range of the project life.

West Beach is oriented significantly different than East Beach. At West Beach, higher energy waves from the east and southeast approach in such a fashion as to cause substantial longshore transport in a westerly direction. This has the effect of producing significant erosion to West Beach, especially in the central part. The extended and reveted point blocks the sand on the East Beach from being transported westerly. Any sand moved from West Beach by longshore transport is not replaced and consequent erosion takes place.

WIND AND WAVE DIRECTION

The dominant onshore winds are easterly and the prevailing onshore winds are from the south and south west. The more powerful waves approach from the east and move considerable amounts of sediment on West Beach in a westerly direction.

CURRENTS

Longshore currents resulting from waves approaching the shore at an oblique angle are the only currents performing significant sediment movement in the study area. The winds and waves characteristic of the study area dictate that the dominant longshore transport direction is from east to west.

STRUCTURAL MODIFICATIONS

Superimposed over the natural geologic and coastal processes described above are the effects of the three modifications performed in the area.

Sand nourishment in 1957 did not éffect the natural processes occurring in the area. The nourishment did provide temporary recreational beaches at the point and West Beach and a more stable beach area at East Beach. The sand applied at the point and on much of West Beach w·s severely eroded and those areas continued to undergo significant deterioration. The sand transported westerly, has contributed to the shoaling of Compo Cove.

The extension and revetment of Sherwood Point has served to stabilize East Beach blocking any movement of sand westerly off the beach. The extended point has also contributed to the erosion of West Beach by cutting off East Beach as a source of sand supply for West Beach.

The groin, at the west end of West Beach, has served to trap sand being moved in a westerly direction by longshore transport. When first constructed in 1957, the groin was low enough to allow sand bypass through wind and wave overtopping. In 1976 an inshore portion of the groin was raised sufficiently to block any sand bypass. Immediately, the beach on the downdrift side of the groin, a segment of State land and Compo Cove Beach (private), underwent substantial erosion and has continued so until the present day.

It is apparent that none of the modifications structured or applied to West Beach area have been entirely successful. The alternative modifications proposed in this report, in concert with the geologic coastal processes acting in the area, are anticipated to produce enhanced and safe recreational beach areas for the life of the project.

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4. Flaherty, Giavara Associates, 1980, Shoreline Stabilization at Sherwood Island State Park and Campo Cove.

5. Stone, J. R. and London, E. H., 1979, Preliminary Surficial Geologic Map of the Sherwood Point and Westport Quadrangles, Connecticut. Connecticut Coastal Area Management Program, 1979.

TABLE 5-1

DESCRIPTION OF EXISTING COASTL

LOCATION	EAST BEACH			SHERWOOD POINT			* WEST BEACH - E	
YEAR	1949	1974	1980	1949	1974	1980	1949	1974
BEACH WIDTH (FT.) (above MHW)	50-75	70-100	70-100	0	0	0	0-50	0
BEACH WIDTH (FT.) (MLW - MHW)	50-200	60-220	80-300	250	210	0	50-200	50-200
COMPOSITION (above MHW)	coarse sand and gravel	sand and sand pebbles	coarse to medium sand and gravel	very rocky	very rocky	armored stone	boulders and cobbles	cobbles and rocks
COMPOSITION (below MHW)	cobbles to shingle, some boulders, fine sand offshore	cobbles, gravel	fine sand and gravel, cobbles at east and west ends	N/A	N/A	N/A	shingle marsh	shingle
SLOPE-Beachface	N/A	1/10	1/10-1/14	N/A	1/30	N/A	N/A	1/20
SLOPE-Nearshore	N/A	1/100	1/100	N/A	1/60-point 1/100-oblique	N/A	N/A	1/100
SLOPE-Inshore	N/A	1/40	N/A	N/A	1/60	N/A	N/A	1/60

*600 feet west o

**extending from

TABLE 5-1

IPTION OF EXISTING COASTLINE

	* WEST BEACH - East Segment			**WEST BEACH - West Segment			COMPO COVE BEACH		
)	1949	1974	1980	1949	1974	1980	1949	1974	1980
	0-50	0	80	50-75	100-180	20-220	0-50	N/A	minimal
	50-200	50-200	50-200	100-300	150-220	180-280	150-east 1,000-west	N/A	150-east 1,000-west
ted e	boulders and cobbles	cobbles and rocks	medium sand, cobbles and shingle	fine sand	sandy	medium to coarse sand	east end- boulders, shingle west end- medium sand	N/A	medium to fine sand cobbles
/A	shingle marsh	shingle	cobbles and shingle	shingle to fine sand	gravel and cobbles with sand	fine sand	east end- boulders, shingle marsh west end- fine sand, some shingle	N/A	east end- cobbles and bedrock west end- fine sand
/A	N/A	1/20	1/20	N/A	1/20	1/30	N/A	N/A	1/14
/A	N/A	1/100	1/100	N/A	1/100	1/100	N/A	N/A	ndulatory, ow slope
/A	N/A	1/60	N/A	N/A	1/60	N/A	N/A	N/A	N/A

*600 feet west of point in 1974 report, 1,500 feet west of point in 1949 report

**extending from end of east segment to Federal groin

TABLE 5-2

MAGNITUDE AND FREQUENCY OF OCCURRENCE OF TIDAL SURGES

TYPE OF STORM	DATE	SURGE HEIGHT OBSERVED STILLWATER ELEVATION (FT. NGVD)	ADJUSTED ELEVATION (FT. NGVD)	REOCCURRENCE INTERVAL (YEARS)
Hurricane	21 Sept 1938	9.2	9.6	1/50
Hurricane	31 Aug 1954	9.2	9.4	1/40
Hurricane	14 Sept 1944	8.8	9.1	1/151
Storm	25 Nov 1950	8.8	9.0	1/15
Storm	7 Nov 1953	8.6	8.8	1/12
Hurricane	12 Sept 1960	8.2	8.3	1/10
Storm	14 Oct 1955	7.9	8.1	1/6
Storm	19 Feb 1960	7.9	8.0	1/5
Storm	12 Nov 1968	7.8	7.9	1/5
Storm	13 Apr 1961	7.7	7.8	1/4
Storm	Ordinary	7.1	-	

TABLE 5-3a

AVERAGE BEACH WIDTHS OVER THE PAST 25 YEARS

LOCATION	YEAR			
	1955 (survey)	1957 (after const.)	1971 (survey)	1980 (survey)
East Beach	30 feet	170 feet	115 feet	100-125 feet
*Sherwood Point (eastern extremity)	0 feet	190 feet	150 feet	N/A
*Sherwood Point Point	100 feet	340 feet	100 feet	N/A
*Sherwood Point (western extremity)	20 feet	230 feet	1000 feet	N/A
West Beach (east end)	20 feet	230 feet	180 feet	25 feet
West Beach (center)	20 feet	N/A	N/A	0 feet
West Beach (west end)	20 feet	150 feet	260 feet	100 feet

* Sherwood Point includes 600 feet east and west of point.

TABLE 5-3b

AVERAGE RATES OF EROSION OVER THE PAST 25 YEARS

EAST BEACH

Average rate of erosion for 1957-1971 - 4 feet/year
Average rate of erosion for 1971-1980 - stable

SHERWOOD POINT

Average rate of erosion for 1957-1971 - 15 feet/year
Average rate of erosion after 1976 construction - stable

WEST BEACH (east)

Average rate of erosion for 1957-1971 - 3.5-4 ft/yr
Average rate of erosion for 1971-1980 - 10 feet/year

WEST BEACH (west)

Average rate of erosion for 1957-1971 - -8 feet/year
(this is actually accretion)
Average rate of erosion for 1971-1980 - 4 feet/year

NOTES: An average rate of 6-7 feet per year
Since 1971 is applied to the entire West Beach

An average rate of 3-4 feet per year from 1971 to 1980 is applied to the entire West Beach

TABLE 5-4

OFFSHORE CHANGES

	EAST BEACH	POINT	WEST BEACH
6 feet	Erosion to 1916 stable to 1980		
12 feet	Erosion to 1916 stable to 1980	General erosion to 1916	Generally eroding to 1916
18 feet	Fluctuation to 1971 stable to 1980	Accretion since 1971 reflecting modification	General accretion except in eastern section where fluctuation occurs

TABLE 5-5

SUMMARY OF BEACH CHANGES

SHORELINE CHANGES

Period	East Beach	Sherwood Point	West Beach (east)	West Beach (west)
1957-1971	Erosion 4 feet/year	Rapid erosion 15 feet/year	Erosion 3.5-4.0 ft/yr	Accretion 8 ft/yr
1971-present	Stable	Stable (since 1976)	Erosion 10 ft/year	Erosion 4 ft/yr

SAND VOLUME TRANSPORT (X1000 cu. yds.)

Period	East Beach	Sherwood Point	West Beach (east)	West Beach (west)
1957-1962	Gain 22.7	Loss 11.1	Gain 45	
1962-1979	Loss 3.9	Loss 6.5	Loss 31	
1971-1980	Gain 3.3	Gain 1.4	Loss 16.2	Gain 4.3
Net	Gain 22.1	N/A	Gain 2.1	

OFFSHORE CHANGES

Period	East Beach	West Beach	West Beach (east & west)
1916	6 foot- erosion 12 foot- erosion 18 foot-erosion	General erosion to 1916	General erosion to 1916 then general accretion except in eastern extremity where fluctuation has occurred
1916-1980	6 foot- stable 12 foot- stable 18 foot- stable	Accretion Since 1971 (structural)	

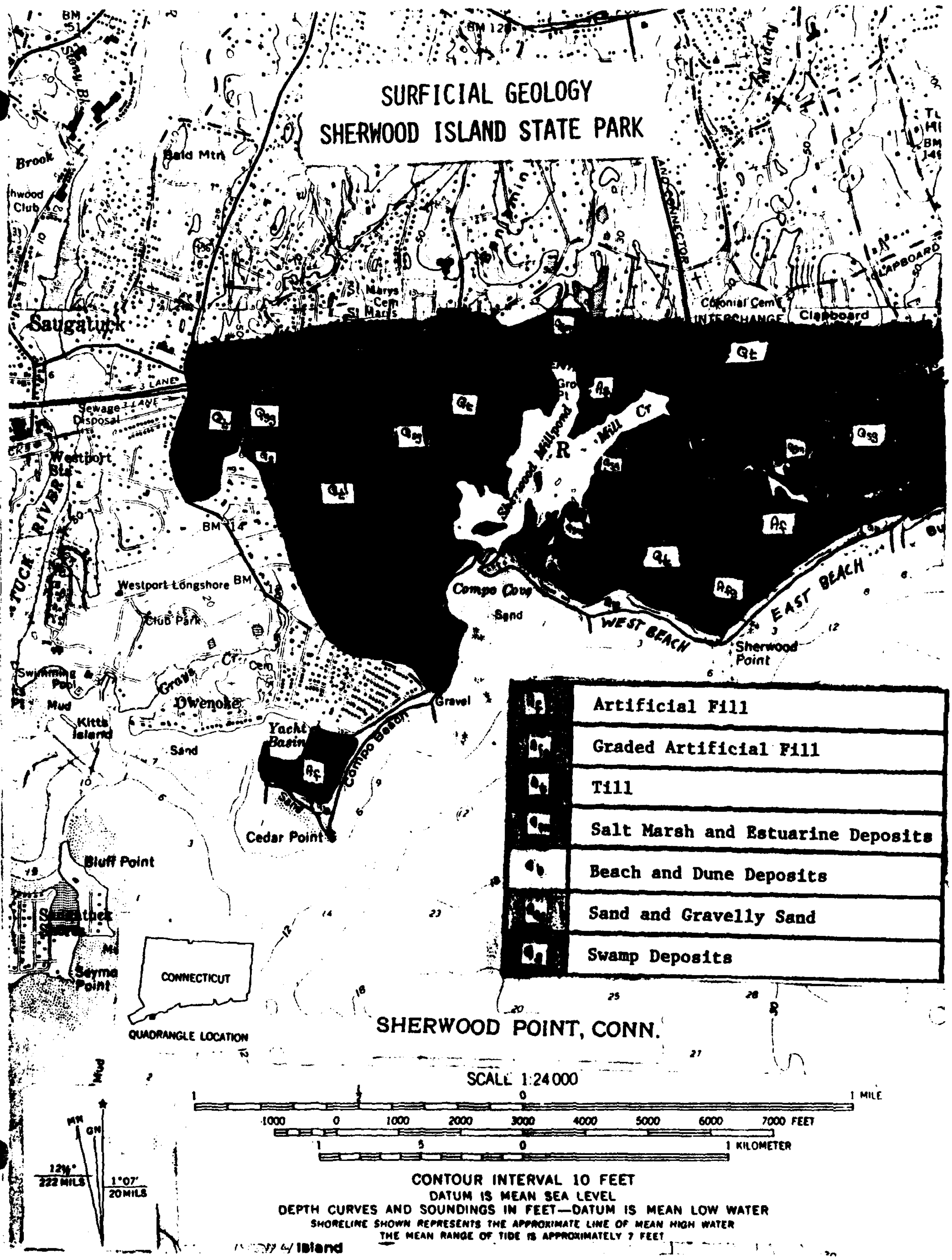
SURFICIAL GEOLOGY
SHERWOOD ISLAND STATE PARK
Artificial Fill
Graded Artificial Fill
Till
Salt Marsh and Estuarine Deposits
Beach and Dune Deposits
Sand and Gravelly Sand
Swamp Deposits
Saugatuck
Westport Sta
Compo Cove
WEST BEACH
EAST BEACH
Sherwood Point
Sherwood Millpond
Mill Cr
Cedar Point
Compo Beach
Yacht Basin
Owenoke
Kitts Island
Bluff Point
CONNECTICUT
QUADRANGLE LOCATION
SHERWOOD POINT, CONN.
SCALE 1:24000
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 7 FEET

PLATE 5-1

RECREATION AND NATURAL RESOURCES

The Sherwood Island State Park area is presently one of Connecticut's largest and most popular recreational areas. The attendance of this area tripled following the construction of a beach erosion project in 1957. The area has presently returned to its pre-construction condition and the attendance is steadily decreasing. This section of the report will discuss the recreational and natural resources needs of the beach.

RECREATIONAL RESOURCES

This recreational facility is the western most of Connecticut's three state-owned beaches. Only 6 percent of Connecticut's shoreline is made up of public recreational beach. Sherwood Island caters almost exclusively to the very heavy populated southwest Connecticut and New York Metropolitan areas. Bordering land is made up of a resort and residential area. Prior to a project done in 1957 Sherwood Island had a very small attendance rate. This attendance was due to the coarse nature of most of the beach, which could not compare with the town beaches and Hammonasset State Beach.

Swimming, although one of the most popular summertime sports, is not the only activity available at the park. Ample picnic tables, ball playing areas, and large grassy sunning areas are also available in addition to the beach. Rough measures of the areas used for walking, picnicing, and other forms of recreational activities total about 6 million square feet. At the present there are ample parking and sanitary facilities available at the park.

PROBLEMS AND NEEDS

The problem at Sherwood Island is the lack of sufficient recreational beach area. There is a need for an improved existing saltwater bathing beach area. Although the surrounding area has several town beaches within its limits, Sherwood Island has the only major recreational park beaches in the area. These beaches are used frequently and often become overcrowded on warm summer days. The lack of usable dry beach space is primarily attributed to constant erosion of the shore by winter storms and occasional hurricanes. Even though this area is protected by Long Island, annual storms that occur in this area are still a major problem.

To preserve and protect this natural resource and provide the people of this area with a healthy recreational area, a program of beach restoration and periodic sand nourishment should be developed with Federal

participation. This would provide for the general public, a continued recreational saltwater bathing facility in the Westport area. It would also guarantee locals that the cost of this periodic beach nourishment for the 50-year period of analysis will be cost-shared by the Federal government.

NATURAL RESOURCES

Sherwood Island State Park is presently a popular area for recreational sport fishing, swimming, picnicing, and sunbathing.

In the Sherwood Island area, there are many forms of vegetation including grass, shrub, and tree species, typical of the Connecticut coastal environment. This vegetation is suitable habitat for rodents and several avian species. Waterfowl in this area include sea ducks, geese, brant, and coot.[1]

Shellfish in the Westport-Long Island sound region include oysters, hard- and soft-shell clams, and bay scallops.[2] There is a small colony of clams, mussels, and snails located in the area to be filled. This area is not considered viable resource since most of the clams are not of legal size. This resource will be relatively undisturbed in the area of Sherwood Point and at or near the existing mean low water line, the seaward limit of the proposed sandfill. Recreational fishermen frequent the rocky Sherwood Point and the existing west groin. The finfish native to this area include striped bass, tautog, weakfish, scup, mackerel, and flounder.[3]

MANAGEMENT OF FINAL ALTERNATIVE PLANS

The recreational and natural resource management of the five alternative plans considered for the study area will be discussed in the following paragraphs. A general understanding of these resources and development trends is helpful in selecting the appropriate solutions.

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[1] The Resources of the New England-New York Region, Chapter 23: pg IX-5.

[2] Ibid. Page IX-9

[3] Ibid. Page IX-9

ALTERNATIVE PLANS CONSIDERED

Four basic alternative plans were considered for the West Beach of Sherwood Island. Each plan, although not uniquely different from the other plans, provides alternative considerations to be investigated in arriving at the most practical and economical solution to the problem. Each plan that includes sand placement will consider three berm widths: 200, 225, and 250 feet. Lowering the existing groin and constructing a low profile groin area also considered in these plans. The fourth plan is a shore management plan. In considering these plans, local management aspects were investigated including improved backshore use, developing additional facilities, improving the existing park activities, increasing the number of lifeguards, developing a youth activities program, etc.

EXTENT AND LOCATION OF LANDS

The beach and park facility are owned and operated by the State. West Beach extends westerly from Sherwood Point for approximately 1,800 feet, and East Beach extends from Sherwood Point easterly for approximately 3,600 feet. The park is located on the south shore of Westport and it is one of Connecticut's three coastal State Parks. It is a fully facilitated State Park and is a natural resource for the State. Since it is owned and operated by the State, they have every intention of developing and maintaining it to fill the needs of the general public. The only lands on the island which are not owned by the State are privately-owned lots; therefore, additional land acquisition to expand the park is unlikely. Any cost incurred to acquire new land or to further implement additional management measures at the beach are the responsibility of the city or State and will not involve the Corps of Engineers.

SOCIAL AND CULTURAL RESOURCES

This section will address the social features of the area as they affect Sherwood Island State Park and the town of Westport. Part of this section includes a letter from the State Historic Preservation Officer, who is involved in the cultural resources of the project.

SOCIAL RESOURCES

INTRODUCTION

This study is being undertaken to determine the feasibility of providing beach erosion control for West Beach, located in Sherwood Island State Park, Westport, Connecticut. Initial studies have indicated positive consideration for Federal action, thereby warranting additional and more detailed project analyses.

This section of the report will identify the social and economic impacts of alternative project plans. A description of the problem, the study area, the without project condition, and proposed problem solutions will be presented within the section.

THE PROBLEM

West Beach is experiencing a serious problem that has significantly reduced the beach area. The beach is approximately 1,800 feet long from the terminal groin, its western limit, east to Sherwood Point. Currently, at mean high water, the beach width varies from 100 feet near the groin structure to 0 feet near the mid-beach area to a 25-foot width near Sherwood Point. This beach has generally been overtopped during frequent, serious winter storms which has helped cause the present deteriorated conditions. The State of Connecticut has requested Federal assistance to restore the beach area by providing for erosion control. Proposed solutions include: beach replenishment, lowering existing groin, constructing a low profile groin, and a shore management plan. Plans involving beach replenishment will consider three different alternative beach berm widths (200, 225, and 250 feet).

THE STUDY AREA

Sherwood Island State Park is Connecticut's first State Park and one of the first in the nation. It is located in the town of Westport, along Long Island Sound, 10 miles west of Bridgeport, Connecticut and 50 miles east of New York City. This park is situated within the heavily populated southwestern Connecticut and New York metropolitan areas, containing approximately 7.4 million people within a 75 mile radius. A large percentage of Connecticut's population lives in close proximity to the shore. The land bordering the shore is almost entirely developed as a private coastal residential area not open to the public. The park is adjacent to the Connecticut Turnpike, Exit 18, making it easily accessible to large segments of the reigon's population.

Park rangers estimate that 90 percent of the people coming to this park seek its water based recreational opportunities. Seventy-five percent of the annual attendance at this park travels from New York City and its suburbs.

Sherwood Island is a regional beach and park, it caters to other parts of Connecticut and New York. Since the status of Westport has no bearing on Sherwood Island's future, investigating Westport's population and economic trends would be useless.

The dense surrounding area population, rises in personal income levels, and trends toward more leisure time have varied park attendance over the past 10 years. Annual attendance figures reveal that from 1971 to 1980 the park's population ranged from a low of 928,000 in 1972 to a high of 1,167,000 in 1977. The 1980 annual attendance figure was 1,040,000, an increase of 25,000 people over the 1979 estimate.

THE BEACH

Sherwood Island State Park contains two distinct beaches (East Beach and West Beach) separated by Sherwood Point. This study will consider only West Beach, which has become badly eroded over the years; East Beach has remained relatively stable. West Beach extends 1,800 feet westerly from Sherwood Point to the existing Federal groin structure, which serves as the western limit of the beach.

Most of the facilities at Sherwood Island State Park are shared by both beaches. These facilities include a combination bathhouse and sanitary facility with flush toilets and running water. The only medical facility is a small first-aid station. Located near the point is a pavilion that contains a restaurant and the park ranger's office. There is also a small concession stand located behind East Beach. Parking is not a problem at Sherwood Island. There is a parking lot behind the pavilion with a capacity for approximately 250 automobiles. Behind East Beach there is also a large open area that is used for parking.

The park has much to offer besides the two beaches. The park has a large wooded picnic area with grassy sections and tables. There are large open playing fields which include a baseball diamond.

Sherwood Island is a State Park designed to accommodate people from other parts of the State who do not have such facilities locally. Seventy-five percent of the annual attendance at the park travels from New York City and its suburbs. The park's easy accessibility to the surrounding population makes its facilities especially appealing to people residing within large metropolitan areas. Annual attendance figures reveal that there is a very high demand for this State Park and its beaches, irrespective of the erosion along the West Beach area. An additional factor which encourages park use is that the water along Long Island Sound is much calmer than water at beaches directly exposed to the ocean.

SALTWATER FACILITIES

The Demand/Supply Relationship - According to the State of Connecticut, only 6 percent of its shoreline is in publicly-owned recreation areas. Shrinking supply of public beach areas resulting from both erosion and increased private development has created a serious problem for the State. Sherwood Island State Park was originally designed to accommodate a peak day capacity of 16,000 bathers and an annual use of 550,00 bathers. Present beach use estimates reveal that over 1 million people annually visit this facility and that 90 percent of them come to enjoy the water-based facilities. This is a doubling of the original design capacity for annual use of the park. As was previously mentioned, park attendance has stabilized at around 1 million visitors annually, even though a serious erosion problem exists at West Beach. State officials believe that with a properly designed beach to complement the park's modern facilities, attendance at the park could be doubled. For a more detailed analysis of supply and demand, refer to the Economics Appendix of this report.

Other Beaches Near the Project Area - There are several excellent public beaches within a short radius of Sherwood Island. These beaches are located in Greenwich, Stamford, Norwalk, Westport, Fairfield, Bridgeport, and Stratford, all in Connecticut. They are all much smaller than the beaches found at Sherwood Island and do not contain the same large public facilities found there such as ample parking and more than a mile of public beach area.

Sherwood Island State Park has the second highest annual attendance of any beach or State Park in Connecticut. In fact, its attendance is more than double that of its closest recreational facility in terms of total annual attendance. Sherwood Island is the western most of the three State-owned parks and is the largest recreational facility in the southwest Connecticut and New York City metropolitan areas. From these two population centers, the park draws most of its attendance.

Without Project Condition - West Beach conditions will continue to deteriorate without implementation of an erosion control project. During serious storms, the beach and the grassy areas along the backshore are overtopped by damaging waves. Rocks near the Sherwood Point section of the beach, some 3 to 4 inches in diameter, litter the beach for a distance of approximately 600 feet in a westerly direction. This creates both aesthetically undesirable conditions and potential safety hazards for beach users. The beach area, especially in the vicinity of the point, is approaching zero feet in width. Erosion has caused some of the beach sand to be washed away, creating a very uneven beach width along the entire length. Additionally, erosion has increased the susceptibility of the beach to damaging wave forces generated during serious storms. These deteriorated conditions will not only persist but will also worsen unless erosion can be controlled. Since park officials have characterized this State Park as being one of Connecticut's most popular recreational areas, problems which decrease the park's beach area may eventually adversely affect its desirability as a recreational resource.

Solutions to the Problem - Presently, there are four alternatives for beach erosion control at West Beach. These plans are described as follows:

Plan 1 - Widening of the existing beach area by the direct placement of suitable sandfill along the entire shoreline extending east from the existing Federal groin structure to Sherwood Point.

Plan 2 - Same as Plan 1 but includes lowering the landward end of the existing groin structure located at the west limit of the study area.

Plan 3 - Same as Plan 2 plus the construction of an intermediate low profile groin structure located between Sherwood Point and the west limit of the study area. The maximum length of the groin will be 510 feet, however, the length will be shorter if a smaller beach berm is utilized.

Plan 4 - Shore Management Planning Guidelines. This involves planning guidelines for managing the use of the backshore facilities and provides additional guidance for future public participation in water related activities. Such as restricting the number of beach users on peak days, designating certain areas for fishing, erecting sand fencing, controlling access to designated areas, and planting grass on the backshore dunes.

Each of the above plans consisting of sandfill (Plans 1, 2, and 3) will consider three different level beach berm widths (200, 225, and 250 feet). The beach area will increase as the beach berm width increases. The low profile groin in Plan 3 will be longer, up to 510 feet maximum, as the beach berm width increases. Analysis of beach capacity with each alternative is discussed in the Economics Appendix of the report.

Mr. Zuena - CDB

CULTURAL RESOURCES

NEDPL-I

27 March 1981
Mr. Wilson/lm/345

Mr. John W. Shannahan
State Historic Preservation Officer
59 South Prospect Street
Hartford, Connecticut 06106

Dear Mr. Shannahan:

You will find inclosed a plan of proposed beach erosion protection at West Beach, Sherwood Island State Park, in Westport. Three alternative plans are proposed:

Plan 1: beach widening to 200, 225, or 250' along 1800' east of the existing groin forming the western end of the beach.

Plan 2: as plan 1, with lowering of the landward end of the existing western groin.

Plan 3: as plan 2, with rock revetment at the western face of Sherwood Point, and new groin approximately halfway down the beach.

A breakwater (Plan 4) 600 feet offshore and paralleling West Beach, and (Plan 5) rock revetment along the entire backshore of West Beach are being dropped from consideration due to cost and environmental effects.

Prior beach widening was done in 1957, and Sherwood Point was extended with fill and revetment in the late 1970's. Therefore, any beach widening or construction would be on fill land, where intact archaeological resources are extremely unlikely. Sand for beach widening will be obtained from commercial sources and possibly from a shallow cove immediately west of the beach. As this cove is far too small and shallow to have formed a historical commercial harbor area, or harbor of refuge, historic resources in the form of sunken vessels appear extremely unlikely, while the extremely active shoreline precludes the possibility of submerged prehistoric sites.

NEDPL-I
Mr. John W. Shannahan

27 March 1981

Mr. Wilson/lm/345

For the above reasons, we anticipate that none of the alternative plans would affect significant historic or archaeological resources. We would appreciate your review and concurrence with these findings, for inclusion in our environmental assessment and feasibility report.

Sincerely,

Incl
As Stated

JOSEPH L. IGNAZIO
Chief, Planning Division

cc: Mr. Wilson
Ms. Yoder
Mr. Bruha - CDB
Planning Div. File

APPENDIX 8

ECONOMICS

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ECONOMICS

I. Introduction

There are four (4) alternatives proposed to solve the erosion problem at the West Beach in Sherwood Island State Park. Three of the alternatives are beach replenishment projects, and one is a shore management plan. If the current situation were to continue unremedied virtually no dry beach area would remain for recreational use at West Beach. This would limit growth in beach attendance at a time when attendance has been growing rapidly. Three of the proposed solutions would involve beach replenishment to stop erosion and create a large beach for recreational usage. Each of these alternatives is evaluated for beach berm widths of 220, 225, and 250 feet. The economic analysis of recreation benefits is based upon the beach berm widths, thus although there are nine (9) variations for the beach replenishment alternatives, and a proposal for a shore management plan, there will only be three (3) different values for recreational benefits.

The estimated recreational benefits will accrue only to the West Beach, which is the sole area of proposed Federal action. Attendance figures were only available for the entire park, and since the East Beach is estimated to be at capacity, any increases in attendance will be assumed to be on the West Beach.

The information used in the benefit analysis was obtained from Sherwood Island State Park officials, Connecticut Department of Recreation officials, previous studies by the Corps of Engineers, and field surveys by Corps of Engineers personnel.

II. Market Area

The market area for Sherwood Island has been identified as a 75 mile radius around the park which includes southern Connecticut and the Greater New York City area. The potential beaches to serve this population would be situated on Long Island Sound from north of Sherwood Island to New York City, and they are for the most part in Connecticut. Only six (6) percent of Connecticut's beaches are considered public beaches and this figure includes municipal beaches restricted to local residents. This situation has resulted in a great demand for beach space and a very high rate of utilization of those beaches accessible to the public.

III. Present Beach Attendance

The attendance figures for Sherwood Island are shown in Table 8-1; annual figures are available for 1957-1980 and monthly figures are shown for selected years in Table 8-2. Based upon the monthly attendance records, the beach season was selected as Memorial Day to Labor Day and the beach season attendance was estimated to be 60 percent of the annual attendance.

TABLE 8-1

ATTENDANCE FIGURES

SHERWOOD ISLAND STATE PARK

	Annual Attendance	Beach Season Attendance	Estimated Beach Attendance	Weekend Day Attendance	Weekday Attendance
1957	159,000	95,400	85,900	2,000	670
1958	338,000	202,800	182,500	4,150	1,400
1959	473,000	283,800	255,400	5,800	1,900
1960	417,000	250,200	225,200	5,100	1,700
1961	555,000	357,100	321,400	7,300	2,400
1962	605,000	332,900	299,600	6,800	2,300
1963	619,000	387,900	349,600	7,900	2,600
1964	738,000	454,900	409,400	9,300	3,100
1965	1,022,000	757,600	681,800	15,500	5,170
1966	1,131,000	666,400	599,800	13,600	4,500
1967	653,530	380,600	342,500	7,800	2,600
1968	824,857	466,800	420,100	9,500	3,200
1969	707,754	422,200	380,000	8,600	2,900
1970	902,231	491,700	442,500	10,100	3,370
1971	1,004,633	516,000	464,400	10,600	3,500
1972	928,485	557,100	501,400	11,400	3,800
1973	987,285	592,400	533,200	12,100	4,000
1974	1,001,000	600,600	540,500	12,300	4,100
1975	1,093,000	655,800	590,200	13,400	4,470
1976	1,100,271	660,200	594,200	13,500	4,500
1977	1,167,472	700,500	630,500	14,300	4,770
1978	1,132,591	679,600	611,600	13,900	4,630
1979	1,015,841	609,500	548,600	12,500	4,170
1980	1,040,000	624,000	561,600	12,800	4,270

TABLE 8-2

MONTHLY ATTENDANCE (SELECTED YEARS)

SHERWOOD ISLAND STATE PARK

	1966	1968	1970	1972	1974	1976
January	29,940	30,994	5,521	39,409	41,345	41,962
February	26,527	23,745	32,864	35,128	37,821	39,564
March	22,727	25,746	36,790	37,434	42,763	49,163
April	66,880	34,995	34,379	47,039	53,916	58,703
May	68,880	65,989	79,201	95,041	76,264	78,086
June	169,701	107,231	110,424	63,661	109,472	164,848
July	305,462	214,463	214,109	262,124	246,025	244,112
August	248,895	181,468	204,652	156,827	174,756	170,923
September	57,567	49,491	61,303	73,057	89,223	79,679
October	55,567	33,994	44,618	55,662	67,138	68,814
November	45,254	31,995	37,154	32,024	40,816	59,121
December	33,941	24,746	41,216	31,079	21,495	45,296
Total	1,131,341	824,857	902,231	928,485	1,001,034	1,100,271

Available estimates are that 90 percent of the beach season attendees use the beach with the remaining 10 percent engaging in other recreational activities in the backshore area.

After adjusting for inclement weather there are 80 days in the beach season, 54 weekdays and 26 weekend days/holidays. Local officials estimate weekend day attendance to be triple weekday attendance. Weekday attendance and weekend day attendance, shown in Table 8-2, were computed in the following manner:

$$26x + 54y = \text{Beach Attendance}$$

$$26x + 54(1/3x) = \text{Beach Attendance}$$

$$26x + 18x = \text{Beach Attendance}$$

$$44x = \text{Beach Attendance}$$

$$x = \text{Beach Attendance} \div 44$$

x = weekend day

y = weekday

IV. Parking

There are 6,000 available parking spaces at Sherwood Island State Park and there are no plans to expand parking. Since park officials estimate that the average car contains 6 people, there is available parking for 36,000 people. However, 10 percent of the visitors use the backshore facilities rather than the beach itself. This places a constraint on maximum daily beach attendance of 90 percent of available parking or 32,400 daily beach users.

V. Turnover Factor

A turnover factor is used to estimate daily attendance for those beaches where beach users visit the beach for less than a full day. A turnover factor of 1.0 is used in those instances where beach users only spend half the day at the beach and there is a maximum daily attendance of double the beach capacity. The information received from park officials is that the turnover factor at Sherwood Island is insignificant. This is consistent with the typical beach user at Sherwood Island State Park, since park officials estimate 75 percent of beach users are from New York State, driving a minimum distance of 50 miles.

VI. Beach Size

The combined dry beach areas for East and West Beach are shown in Table 8-3 for 1957-1980. The projections under the with and without project conditions are also shown in Table 8-3.

The East Beach is stable with a dry beach area of 375,000 ft^2 while the West Beach is suffering serious erosion problems. Table 8-3 shows that the West Beach will have only 40,000 square feet of useable dry beach remaining by 1982. Under the alternative proposed projects the West Beach will have a dry beach area of either 540,000, 585,000, or 630,000 square feet, with Plans 1, 2, and 3, respectively, and approximately 80,000 square feet with Plan 4.

The West Beach is expected to stabilize in 1982 with the beach size at 40,000 square feet. This stabilization will be the result of a regrading program performed by the State. At this point, any further erosion, while affecting the shoreline, would not affect the remaining beach. Although there would remain a theoretical optimum capacity of 530 beach users and a maximum capacity of 1,200 beach users, the effects of the erosion on the surrounding shore would serve to make West Beach less desirable; therefore, it is not expected that the attendance would reach its maximum capacity. For this reason, for the purpose of the benefit analysis on West Beach, it is assumed that the attendance under the without condition will be effectively zero.

TABLE 8-3

BEACH SIZE (DRY BEACH AREA)

SHERWOOD ISLAND STATE PARK

	1955 (before constr.)	1957 (after constr.)	1971	1980	1982
West Beach	36,000	306,000	360,000	75,000	40,000
East Beach	90,000	510,000	345,000	375,000	375,000
TOTAL	126,000	816,000	705,000	450,000	415,000

VII. Utilization of Dry Beach Area - Overcrowding

The information on daily attendance and beach size was used in conjunction with a theoretical optimum of 75 ft^2 per person to determine the percent utilization of the beach area at Sherwood Island.

This information is shown in Table 8-4 for 1957-1980. After the beach space at Sherwood Island was increased in 1957, there was a trend toward increasing utilization of the beach which reached its maximum in the 1970's, at over 200 percent. For the purposes of this study, 225 percent of the optimum square feet per person figure was considered the maximum beach utilization rate. This figure places a constraint upon maximum daily beach attendance based upon present beach size of 11,250 beach users under the without project condition, and 27,450, 28,800, or 30,150 daily beach users under the with project condition.

TABLE 8-4

BEACH SIZE CAPACITY AND UTILIZATION INDEX

SHERWOOD ISLAND STATE PARK

	Beach Size	Theoretical Seasonal Capacity	Theoretical Daily Capacity	Utilization Index
1957	126,000	74,000	1,680	116.0
1958	816,000	480,000	10,900	38.0
1960	808,000	475,000	10,800	54.0
1961	799,000	471,000	10,700	48.0
1962	782,000	458,000	10,400	65.0
1963	774,000	453,000	10,300	77.0
1964	765,000	449,000	10,200	91.0
1965	757,000	444,000	10,100	154.0
1966	748,000	440,000	10,000	136.0
1967	740,000	436,000	9,900	79.0
1968	731,000	427,000	9,700	98.0
1969	723,000	422,000	9,600	90.0
1970	714,000	418,000	9,500	106.0
1971	705,000	414,000	9,400	112.0
1972	677,000	383,000	8,700	131.0
1973	650,000	352,000	8,000	151.0
1974	620,000	321,000	7,300	168.0
1975	595,000	295,000	6,700	200.0
1976	570,000	286,000	6,500	208.0
1977	540,000	282,000	6,400	224.0
1978	515,000	277,000	6,300	221.0
1979	485,000	268,000	6,100	205.0
1980	450,000	264,000	6,000	213.0
1981	420,000	242,000	5,500	
1982	375,000	220,000	5,000	

VII. Recreational Unit Day Value

Sherwood Island State Park provides general recreational opportunities such as swimming, sunbathing, picnicking, and softball. There is a large grassy area behind the beach, a pavilion with a restaurant and complete bathhouse facilities. The State park is a short distance from I-95 with its own exit.

The State of Connecticut charges a $2.00 entrance fee per car which would average $0.33 per person, using six people per car. This amount is considered to be below the unit day value for Sherwood Island. The general recreation unit day value for Sherwood Island was estimated at $2.10 under the without condition due to overcrowding. Under the with project condition there would be an increase to $2.30 because of the alleviation of crowding. Over the life of the project due to increasing attendance the unit day value would decrease to the original $2.10. Based upon Tables K31 and K32 in ER 1105-2-300, points and dollar values were assigned to a recreation day experience at Sherwood Island. (See Table 8-5.)

TABLE 8-5

UNIT DAY VALUE

SHERWOOD ISLAND STATE PARK

	WITHOUT PROJECT	WITH PROJECT
Recreation Experience several general activities	8	8
Availability of Opportunity one or two within one hour travel time, none within 45 minutes travel time	9	9
Carrying Capacity * optimum facilities to conduct activity at site	4	10
Accessibility good access, high standard road to site, good access within site	16	16
Environmental Quality above average aesthetic quality	7	7
TOTAL POINT VALUE	44	50
Unit Day Recreation Value	$2.10	$2.30

* Varies due to overcrowding

The travel cost estimate of willingness to pay was not used to estimate a recreation day value. Use was estimated by a site specific model while the travel cost method requires that use be estimated based upon the relationship of trip generation to distance from the site. The contingent valuation method was not used due to a lack of the necessary time and money to conduct the required surveys and other studies.

IX. Future Beach Attendance

Future beach attendance at Sherwood Island was projected using the econometric modelling capabilities of Data Resources Inc. An ordinary least squares regression was done with historical beach attendance as the dependent variable and many different independent variables were tried, such as: real retail gasoline prices (1972), real expenditures on spectator amusements, New York and Connecticut population, beach size, number of registered automobiles in New York and Connecticut, an overcrowding index, real per capita income (1972), and total hours worked.

A variety of test statistics are provided with the regression enabling the best fitting regression line to be chosen from among all the different combinations attempted. The best fitting regression line was found with the combination of the following four independent variables: New York and Connecticut populations, beach size, the overcrowding index, and New York and Connecticut registered automobiles. The number of people and automobiles were weighted in proportion to their representation among beach users.

These 4 independent variables have their historical values and projected future values shown in Tables 8-6 a and b. The historical values for population and automobiles, and their future values were obtained from DRI data banks which result from DRI's U.S. model. The historical beach size information is the result of Corps of Engineers field surveys, and the future beach sizes result from the proposed alternative beach replenishment plans. The overcrowding index was the result of analyzing beach attendance, beach size, and the theoretical optimum capacity of 75 square feet per person.

Beach attendance has increased throughout the period 1957-1980 although erosion has continually decreased the beach size during the same period. The population of the market area has tow clear trends; a steady increase until the early 1970's and then a steady decrease until 1980. It appears that since the market area is very densely populated and urbanized and there are very few available public beaches there exists a high level of unsatisfied demand. The high level of unsatisfied demand appears to explain increasing attendance in the 1970's at the same time as decreasing beach size and a decreasing market area population.

Table 8-6a Independent Variables

	OVERCROWD4	OVERCROWD3		OVERCROWD2A	OVERCROWD1	BEACHCARAL
1957	116.000	116.000	57	116.000	116.000	3.425
1958	38.000	38.000	58	38.000	38.000	3.502
1959	54.000	54.000	59	54.000	54.000	3.604
1960	48.000	48.000	60	48.000	48.000	3.630
1961	70.000	70.000	61	70.000	70.000	3.725
1962	65.000	65.000	62	65.000	65.000	3.854
1963	77.000	77.000	63	77.000	77.000	3.990
1964	91.000	91.000	64	91.000	91.000	4.132
1965	101.000	101.000	65	101.000	101.000	4.296
1966	99.000	99.000	66	99.000	99.000	4.353
1967	79.000	79.000	67	79.000	79.000	4.405
1968	98.000	98.000	68	98.000	98.000	4.602
1969	90.000	90.000	69	90.000	90.000	4.746
1970	106.000	106.000	970	106.000	106.000	4.893
1971	112.000	112.000	971	112.000	112.000	5.029
1972	131.000	131.000	972	131.000	131.000	5.126
1973	151.000	151.000	973	151.000	151.000	5.344
1974	168.000	168.000	974	168.000	168.000	5.436
1975	200.000	200.000	975	200.000	200.000	5.500
1976	208.000	208.000	76	208.000	208.000	5.531
1977	224.000	224.000	77	224.000	224.000	5.580
1978	221.000	221.000	78	221.000	221.000	5.682
1979	205.000	205.000	79	205.000	205.000	5.728
1980	213.000	213.000	80	213.000	213.000	5.734
1981	225.000	225.000	81	225.000	225.000	5.787
1982	105.000	95.000	82	100.000	225.000	5.828
1983	107.897	96.344	83	101.542	225.000	5.923
1984	110.874	97.707	84	103.107	225.000	6.033
1985	113.934	99.089	85	104.697	225.000	6.132
1986	117.078	100.490	86	106.311	225.000	6.221
1987	120.308	101.912	87	107.951	225.000	6.303
1988	123.628	103.353	88	109.615	225.000	6.380
1989	127.039	104.815	89	111.305	225.000	6.455
1990	130.545	106.298	1990	113.021	225.000	6.522
1991	134.147	107.801	1991	114.764	225.000	6.589
1992	137.848	109.326	1992	116.533	225.000	6.657
1993	141.652	110.873	1993	118.330	225.000	6.726
1994	145.560	112.441	994	120.154	225.000	6.796
1995	149.577	114.032	995	122.007	225.000	6.866
1996	153.704	115.645	996	123.888	225.000	6.937
1997	157.945	117.280	997	125.798	225.000	7.009
1998	162.304	118.939	998	127.738	225.000	7.081
1999	166.782	120.622	999	129.707	225.000	7.155
2000	171.384	122.328	000	131.707	225.000	7.229
2001	176.113	124.058	001	133.738	225.000	7.300
2002	180.973	125.813	002	135.800	225.000	7.300
2003	185.966	127.593	003	137.894	225.000	7.300
2004	191.098	129.396	004	140.020	225.000	7.300
2005	196.371	131.226	005	142.178	225.000	7.300
2006	201.789	133.084	006	144.371	225.000	7.300
2007	207.357	134.967	007	146.597	225.000	7.300
2008	213.079	136.876	2008	148.857	225.000	7.300
2009	218.958	138.812	2009	151.152	225.000	7.300
2010	225.000	140.77	2010	153.482	225.000	7.300
2011	225.000	142.76	2011	155.849	225.000	7.300
2012	225.000	144.78	2012	158.252	225.000	7.300
2013	225.000	146.83	2013	160.692	225.000	7.300
2014	225.000	148.91	2014	163.169	225.000	7.300
2015	225.000	151.01	2015	165.685	225.000	7.300
2016	225.000	153.15	2016	168.240	225.000	7.300
[illegible]		55.3[illegible]	2017	170.[illegible]	225.000	7.300
		57.5			22	
	--- ---	59.7			22	
		2.0[illegible]			22	
	------	4.2			22	
2022	225.000	166.620	2022	184.416	225.000	7.300
2023	225.000	168.977	023	187.259	225.000	7.300
2024	225.000	171.368	024	190.146	225.000	7.300
2025	225.000	173.798	025	193.078	225.000	7.300
2026	225.000	176.250	026	196.055	225.000	7.300
2027	225.000	178.743	027	199.078	225.000	7.300
2028	225.000	181.271	028	202.147	225.000	7.300
2029	225.000	183.835	029	205.264	225.000	7.300
2030	225.000	186.436	030	208.429	225.000	7.300
2031	225.000	189.073	031	211.642	225.000	7.300
2032	225.000	191.747	032	214.906	225.000	7.300
2033	225.000	194.468	033	218.219	225.000	7.300
2034	225.000	197.216	034	221.584	225.000	7.300
2035	225.000	200.000	035	225.000	225.000	7.300

Table 8-6b Independent Variables

BEACHPOPALL	BEACHSIZ		BEACHSIZE2	EACHSIZE3	BEACHSIZE4
13.870	126,000.0	1957	126,000.000		
13.062	816,000.0	1958	816,000.000		
13.145	808,000.0	1959	808,000.000		
13.265	799,000.0	1960	799,000.000		
13.442	791,000.0	1961	791,000.000		
13.637	782,000.0	1962	782,000.000		
13.777	774,000.0	1963	774,000.000		
13.891	765,000.0	1964	765,000.000		
14.015	757,000.0	1965	757,000.000		
14.108	748,000.0	1966	748,000.000		
14.195	740,000.0	1967	740,000.000		
14.279	731,000.0	1968	731,000.000		
14.329	723,000.0	1969	723,000.000		
14.453	714,000.0	1970	714,000.000		
14.533	705,000.0	1971	705,000.000		
14.527	677,000.0	1972	677,000.000		
14.415	650,000.0	1973	650,000.000		
14.331	620,000.0	1974	620,000.000		
14.335	595,000.0	1975	595,000.		
14.300	570,000.0	1976	570,000.		
14.206	540,000.0	1977	540,000.		
14.083	515,000.0	1978	515,000.		
14.006	485,000.0	1979	485,000.		
13.929	450,000.0	1980	450,000.		
13.866	420,000.0	1981	420,000.	420,000.000	420,000.000
13.809	375,000.0	1982	960,000.	,000.000	1,005,000.000
13.751	375,000.0	1983	960,000.	,000.000	1,005,000.000
13.713	375,000.0	1984	960,000.	,000.000	1,005,000.000
13.688	375,000.0	1985	960,000.	,000.000	1,005,000.000
13.668	375,000.0	1986	960,000.	,000.000	1,005,000.000
13.647	375,000.0	1987	960,000.	,000.000	1,005,000.000
13.623	375,000.0	1988	960,000.	,000.000	1,005,000.000
13.596	375,000.0	1989	960,000.	,000.000	1,005,000.000
13.566	375,000.0	1990	960,000.	,000.000	1,005,000.000
13.536	375,000.0	1991	960,000.	,000.000	1,005,000.000
13.507	375,000.0	1992	960,000.	,000.000	1,005,000.000
13.477	375,000.0	1993	960,000.	,000.000	1,005,000.000
13.448	375,000.0	1994	960,000.	,000.000	1,005,000.000
13.419	375,000.0	1995	960,000.	,000.000	1,005,000.000
13.389	375,000.0	1996	960,000.	,000.000	1,005,000.000
13.360	375,000.0	1997	960,000.	,000.000	1,005,000.000
13.331	375,000.0	1998	960,000.	,000.000	1,005,000.000
13.301	375,000.0	1999	960,000.	,000.000	1,005,000.000
13.272	375,000.0	2000	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2001	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2002	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2003	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2004	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2005	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2006	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2007	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2008	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2009	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2010	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2011	960,000.0	,000.000	1,005,000.000
13.300	375,000.0	2012	960,000.0	,000.000	1,005,000.000
13.300	375,000.0	2013	960,000.0	,000.000	1,005,000.000
13.300	375,000.0	2014	960,000.0	,000.000	1,005,000.000
13.300	375,000.0	2015	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2016	960,000.	,000.000	1,005,000.000
13.300	375,000.0	[illegible]	[illegible]	5,000.000	1,005,000.000
				5,000.000	1,005,000.000
---	---			5,000.000	1,005,000.000
				,000.000	1,005,000.000
				,000.000	1,005,000.000
13.300	375,000.0	2022	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2023	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2024	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2025	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2026	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2027	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2028	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2029	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2030	960,000.	,000.000	1,005,000.000
13.300	375,000.0	2031	960,000.	,000.000	1,005,000
13.300	375,000.0		000.0	,000.000	1,005,000.
13.300	375,000.0		000.0	,000.000	1,005,000.000
13.300	375,000.0		000.0	,000.000	1,005,000.000
13.300	375,000.000		000.0	,000.000	1,005,000.000

The results of the regression analysis are shown in Table 8-7. These results were arrived at by regressing the time series of the independent variables on the dependent variable, beach attendance, for the years 1957-1980. Figure 8-1 is a comparison of actual beach attendance from 1957-1980 with the beach attendance predicted by the regression equation over the same period of time. The test statistic results are born out graphically, i.e., the regression equation provides a very good fit to the actual attendance. The significant variation in 1965-1966 is the result of unusually good weather which caused abnormally high attendance. The equation resulting from the analysis is given below:

Beach attendance = +1642 (overcrowding index) + .4 (beach size) + 107,000 (NY and CT registered automobiles) - 41,000 (NY and CT population)

Table 8-7 displays several tests which indicate the statistical sigificance of the regression analysis. The t-statistic is shown for each independent variable for a two tailed test and they are all statistically significant at greater than the .01 significance level. The R-Bar squared has a value of .94 meaning that 94 percent of the variance in the dependent variable is explained by the regression equation. The Durbin-Watson statistic is a test for the presence of autocorrelation: its value of .9 is significant to the .05 level for a two-tailed test indicating there is not autocorrelation. The OLS regression was done twice with one of the sets of coefficients being the Beta coefficients. Beta coefficients are used to determine the relative importance of the independent variable in explaining the dependent variable. The results show population and automobiles to be of similar strength, and to be twice as strong as beach size and the overcrowding index. Tests were not conducted for the presence of multi-collinearity or heteroscedasticity which are not important problems for time series data. The F statistic of 1,200 was significant to the .01 level.

The next step after testing for the validity of the regression equation was to solve for the dependent variable. The regression equation was solved by computing the future values for the independent variables; and the output is shown in Table 8-8. The five columns in Table 8-8 are historical beach attendance from 1957-1980, estimated beach attendance with the project from 1981-2035, and estimated beach attendance without the project from 1981-2035. The estimated beach attendance without the project differs from the with project condition because the values for beach size and overcrowding differ under the two conditions. The projections for the without project condition do not represent estimated future attendance since there is not sufficient beach space for increased attendance. The projections under the without condition represent an estimate of future unsatisfied demand if the project were not built.

TABLE 8-7

REGRESSION ANALYSIS, TEST STATISTICS, AND THE REGRESSION EQUATION

ORDINARY LEAST SQUARES

NUAL(1957 TO 1980)   24 OBSERVATIONS
PENDENT VARIABLE: BEACHATTENDORIG

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
)	1642.14	479.3	3.426	OVERCROWD2A
2)	0.445238	0.08230	5.410	BEACHSIZE2
3)	106562	3.288E+04	3.241	BEACHCARALL
4)	-40789.6	7031	-5.802	BEACHPOPALL

-BAR SQUARED: 0.9370   (RELATIVE TO Y=0, RBSQ: 0.9936)
JRBIN-WATSON STATISTIC: 0.9022
ANDARD ERROR OF THE REGRESSION: 3.641E+04   NORMALIZED: 0.08587

ORDINARY LEAST SQUARES

NUAL(1957 TO 1980)   24 OBSERVATIONS
PENDENT VARIABLE: BEACHATTENDORIG

	BETA COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
)	0.502384	0.1466	3.426	OVERCROWD2A
)	0.676533	0.1250	5.410	BEACHSIZE2
)	1.12628	0.3475	3.241	BEACHCARALL
)	-1.27462	0.2197	-5.802	BEACHPOPALL

-BAR SQUARED: 0.9370   (RELATIVE TO Y=0, RBSQ: 0.9936)
-STATISTIC(3,20): 1200
JRBIN-WATSON STATISTIC: 0.9022
ANDARD ERROR OF THE REGRESSION: 3.641E+04   NORMALIZED: 0.08587

TH1: EQUATION
BEACHATTEND= + <1642.14>*OVERCROWD2A + <0.445238>*BEACHSIZE2 &&
+ <106562>*BEACHCARALL - <40789.6>*BEACHPOPALL

TABLE 8-8 FUTURE ATTENDANCE PROJECTIONS

YEAR	Historical Beach Attendance	Without Project	Estimated Beach Attendance 200 ft. Berm	225 ft. Berm	250 ft. Berm
1957	85,900.0	N/A	N/A	N/A	N/A
1958	182,500.0	N/A	N/A	N/A	N/A
1959	255,400.0	N/A	N/A	N/A	N/A
1960	225,200.0	N/A	N/A	N/A	N/A
1961	321,400.0	N/A	N/A	N/A	N/A
1962	299,600.0	N/A	N/A	N/A	N/A
1963	349,100.0	N/A	N/A	N/A	N/A
1964	409,400.0	N/A	N/A	N/A	N/A
1965	450,000.0	N/A	N/A	N/A	N/A
1966	435,000.0	N/A	N/A	N/A	N/A
1967	342,500.0	N/A	N/A	N/A	N/A
1968	420,100.0	N/A	N/A	N/A	N/A
1969	380,000.0	N/A	N/A	N/A	N/A
1970	442,500.0	N/A	N/A	N/A	N/A
1971	464,400.0	N/A	N/A	N/A	N/A
1972	501,400.0	N/A	N/A	N/A	N/A
1973	533,200.0	N/A	N/A	N/A	N/A
1974	540,500.0	N/A	N/A	N/A	N/A
1975	590,200.0	N/A	N/A	N/A	N/A
1976	594,200.0	N/A	N/A	N/A	N/A
1977	630,500.0	N/A	N/A	N/A	N/A
1978	611,600.0	N/A	N/A	N/A	N/A
1979	548,600.0	N/A	N/A	N/A	N/A
1980	561,600.0	N/A	N/A	N/A	N/A
1981	N/A	607,528.0	607,528.0	607,528.0	N/A
1982	N/A	594,161.1	621,111.4	649,357.8	607,528.0
1983	N/A	606,753.2	635,910.2	664,481.8	677,604.3
1984	N/A	619,933.6	651,328.5	680,233.1	694,954.0
1985	N/A	631,584.8	665,249.2	694,494.9	713,023.5
1986	N/A	641,836.0	677,802.1	707,396.9	729,698.6
1987	N/A	651,432.2	689,733.2	719,685.4	745,112.4
1988	N/A	660,696.6	701,364.2	731,682.4	760,014.2
1989	N/A	669,713.4	712,781.7	743,474.5	774,729.3
1990	N/A	678,043.6	723,546.6	754,622.9	789,347.9
1991	N/A	686,444.9	734,417.0	765,885.7	803,434.5
1992	N/A	694.917.9	745,394.1	777,264.4	817,751.0
1993	N/A	703,463.5	756,479.2	788,760.5	832,302.4
1994	N/A	712,082.5	767,673.5	800,375 [illegible]	847,094.2
1995	N/A	720,775.6	778,978.4	812,110.7	862,131.6
1996	N/A	729,543.6	790,395.2	823,967.8	877,420.3
1997	N/A	738,387.3	801,925.2	835,948.2	892,965.9
1998	N/A	747,307.6	813,569.7	848,053.6	908,774.3
1999	N/A	756,305.3	825,330.1	860,285.5	924,851.4
2000	N/A	765,381.2	837,207.9	872,645.4	941,203.3
2001	N/A	771,846.7	846,514.8	882,445.6	957,836.4
2002	N/A	771,846.7	849,396.5	885,831.7	972,067.6
2003	N/A	771,846.7	852,318.9	889,270.0	980,047.6
2004	N/A	771,846.7	855,282.7	892,761.3	988,247.8
2005	N/A	771,846.7	858,288.4	896,306.4	996,674.2
2006	N/A	771,846.7	861,336.6	899,906.2	1,005,333.2
2007	N/A	771,846.7	864,427.9	903,561.5	1,014,231.1
2008	N/A	771,846.7	867,563.0	907,273.2	1.023,374.5
2009	N/A	771,846.7	870,742.3	911,042.1	1.032,770.3
2010	N/A	771,846.7	873,966.7	914,869.1	1,042,425.2
					1.052,346.6

TABLE 8-8 FUTURE ATTENDANCE PROJECTIONS (Cont.)

YEAR	Historical Beach Attendance	Without Project	Estimated Beach Attendance 200 ft. Berm	225 ft. Berm	250 ft. Berm
2011	N/A	771,846.7	877,236.7	918,755.1	1,052,346.6
2012	N/A	771,846.7	880,552.9	922,701.0	1,052,346.6
2013	N/A	771,846.7	883,916.1	926,707.7	1,052,346.6
2014	N/A	771,846.7	887,326.8	930,776.3	1,052,346.6
2015	N/A	771,846.7	890,785.7	934,907.5	1,052,346.6
2016	N/A	771,846.7	894,293.6	939,102.5	1,052,346.6
2017	N/A	771,846.7	897,851.1	934,362.1	1,052,346.6
2018	N/A	771,846.7	901,459.0	947,687.4	1,052,346.6
2019	N/A	771,846.7	905,117.8	925,079.5	1,052,346.6
2020	N/A	771,846.7	908,828.2	956,539.2	1,052,346.6
2021	N/A	771,846.7	913,591.5	961,067.7	1,052,346.6
2022	N/A	771,846.7	916,407.9	965,666.0	1,052,346.6
2023	N/A	771,846.7	920,278.2	970,335.2	1,052,346.6
2024	N/A	771,846.7	924,203.3	975,076.4	1,052,346.6
2025	N/A	771,846.7	928,183.8	979,890.7	1,052,346.6
2026	N/A	771,846.7	932,220.7	984,779.2	1,052,346.6
2027	N/A	771,846.7	936,314.7	989,743.1	1,052,346.6
2028	N/A	771,846.7	940,466.6	994,783.5	1,052,346.6
2029	N/A	771,846.7	944,677.2	999,901.6	1,052,346.6
2030	N/A	771,846.7	948,947.4	1,005,098.7	1,052,346.6
2031	N/A	771,846.7	953,287.0	1,010,375.9	1,052,346.6
2032	N/A	771,846.7	957,669.9	1,015,734.4	1,052,346.6
2033	N/A	771,846.7	962,123.9	1,021,175.6	1,052,346.6
2034	N/A	771,846.7	966,461.0	1,026,700.7	1,052,346.6
2035	N/A	771,846.7	971,821.7	1,032,310.9	1,052,346.6

In the same manner as was done for the without project condition there are constructed two additional projections for the other two possible alternatives. All previous evaluation of the with project condition was done for the 225 foot berm, however, projections were also derived for a 200 foot berm and a 250 foot berm. The same regression equation was used but the future values input to the equation are different for the beach size and the overcrowding index. These different values are shown in Table 6a, b and the project future beach attendance for a 200 foot berm and a 250 foot berm are shown in Table 8-8.

There are two possible constraints upon attendance projections, beach capacity and parking capacity. The daily beach capacity under the with project condition varies depending upon the three beach berm widths from 27,450 to 28,000 to 30,150 while the daily parking capacity is constant at 32,400.

Under the with project condition the growth in beach attendance would not be constrained by either factor during the 50 year project life. In 2035 with the maximum projected beach attendance for the 225 foot berm the daily weekend attendance would be 23,463 which will be well below the minimum beach capacity constraint of 27,450. Under the without project condition there would not be any growth in beach attendance since the present beach capacity has already reached its maximum level. In Figure 8-2 the growth of attendance under the three alternatives is shown and the upper limits of attendance are shown as higher than the maximum projected attendance.

X. Recreational Benefit/Other Benefits

Recreational Benefits

The benefit analysis for Sherwood Island State Park, shown in Table 8-9, was based upon a project life of 50 years, a 7 3/8 percent Federal interest rate, and a unit day value which varies from $2.30 to $2.10. Average annual recreational benefits accrue to the project due to the increased attendance during the project life contrasted with the projected stable attendance under the without project condition. The future benefits computed in Table 8-9 were discounted to the first year of the project life and then annualized over the project life.

The annual recreational benefits were computed for the three alternative beach berm widths of 200 feet, 225 feet, and 250 feet. The analysis of recreational benefits for the 225 and 250 foot berms are shown in Table 8-10 and Table 8-11, and they were computed in the same manner as for the 200 feet berm. A comparison of the average annual recreation benefits for the proposed alternatives is shown in Table 8-12.

TABLE 8-9

AVERAGE ANNUAL EXPECTED RECREATIONAL BENEFITS

SHERWOOD ISLAND STATE PARK

(50 Year Project Life, 7 3/8%, 1981 Price Level, 200' Berm)

	1982	1992	2002	2012	2022	2032
Unit Day Value With Project	$2.30	$2.25	$2.20	$2.20	$2.15	$2.10
Unit Day Value W/O Project	$2.00	$2.00	$2.00	$2.00	$2.00	$2.00
Seasonal Beach Attendance With Project	621,000	745,000	849,000	880,000	916,000	958,000
Seasonal Beach Attendance W/O Project	495,000	495,000	495,000	495,000	495,000	495,000
Recreational Value With Project	$1,428,000	$1,676,000	$1,868,000	$1,936,000	$1,969,000	$2,012,000
Recreational Value W/O Project	$ 990,000	$ 990,000	$ 990,000	$ 980,000	$ 990,000	$ 990,000
Recreational Benefit 200' Berm	$ 438,000	$ 686,000	$ 878,000	$ 946,000	$ 979,000	$1,022,000
Equivalent Average Annual Recreational Benefit	$697,000					

TABLE 8-10

AVERAGE ANNUAL EXPECTED RECREATIONAL BENEFITS

SHERWOOD ISLAND STATE PARK

(50 Year Project Life, 7 3/8%, 1981 Price Level 225' Berm)

	1982	1992	2002	2012	2022	2032
Unit Day Value With Project	$2.30	$2.25	$2.20	$2.15	$2.10	$2.10
Unit Day Value W/O Project	$2.00	$2.00	$2.00	$2.00	$2.00	$2.00
Seasonal Beach Attendance With Project	649,000	777,000	886,000	923,000	966,000	1,016,000
Seasonal Beach Attendance W/O Project	495,000	495,000	495,000	495,000	495,000	495,000
Recreational Value With Project	$1,493,000	$1,748,000	$1,949,000	$1,984,000	$2,029,000	$2,134,000
Recreational Value W/O Project	$ 990,000	$ 990,000	$ 990,000	$ 990,000	$ 990,000	$ 990,000
Recreational Benefit 225' Berm	$ 503,000	$ 758,000	$ 959,000	$ 994,000	$1,039,000	$1,144,000
Equivalent Average Annual Recreational Benefit	$767,000					

TABLE 8-11

AVERAGE ANNUAL EXPECTED RECREATIONAL BENEFITS

SHERWOOD ISLAND STATE PARK

(50 Year Project Life, 7 3/8%, 1981 Price Level, 250' Berm)

	1982	1992	2002	2012	2022	2032
Unit Day Value With Project	$2.30	$2.20	$2.10	$2.10	$2.10	$2.10
Unit Day Value W/O Project	$2.00	$2.00	$2.00	$2.00	$2.00	$2.00
Seasonal Beach Attendance With Project	678,000	832,000	980,000	1,052,000	1,052,000	1,052,000
Seasonal Beach Attendance W/O Project	495,000	495,000	495,000	495,000	495,000	495,000
Recreational Value With Project	$1,559,000	$1,830,000	$2,058,000	$2,209,000	$2,209,0000	$2,209,000
Recreational Value W/O Project	$ 990,000	$ 990,000	$ 990,000	$ 990,000	$ 990,000	$ 990,000
Recreational Benefit 250' Berm	$ 569,000	$ 840,000	$1,219,000	$1,219,000	$1,219,000	$1,219,000
Equivalent Average Annual Recreational Benefit	$867,000					

Other Benefits

Erosion at Sherwood Island State Park's West Beach is estimated to be 4 feet a year, along its 1,800-foot length, or 7,200 square feet annually. Without the Federal project there would be continued loss of land for the 50 year life of the project. The prevention of this loss of land is a benefit which would accrue to each of the three proposed alternatives containing sandfill. The benefit is based upon an average value of shorefront land of $300 per square foot for an annual benefit of $3.00 times 7,200 square feet, or $21,600.

The other significant benefit to the proposed project is a recreational fishing benefit attributable to the construction of the stone groin in Plan 3. The Fish and Wildlife Service estimated the average annual benefit to the stone groin from recreational fishing would be $9,000 in 1980 prices.

The lowering of the existing Federal groin structure will allow wind-blown sand to nourish a small area of State-owned beach to the west of this structure. The area in question is small; therefore, the benefits accrued from the lowering of the groin will only increase the recreational benefits by a small percentage. This benefit only applies to Plans 2 and 3.

These above-mentioned benefits are added to the recreational benefits shown in Tables 8-9, 8-10, and 8-11 for the three berm widths. The sum of these benefits are reflected in Table 8-12.

XI. Justification

Based upon the economic analysis of the proposed project alternatives for Sherwood Island State Park, Plans 1, 2, and 3 are economically justified. Table 8-12 below shows the annual benefits and costs, the benefit to cost ratio, and the net benefits for the 10 proposed alternatives.

TABLE 8-12

ECONOMIC ANALYSIS

SHERWOOD ISLAND STATE PARK

	TOTAL AVERAGE ANNUAL BENEFITS	AVERAGE ANNUAL COSTS	BENEFIT TO COST RATIO	NET BENEFITS
Plan 1				
200' Berm	$718,600	$103,000	6.98	$615,600
225' Berm	$788,600	$168,500	4.68	$620,100
250' Berm	$888,600	$268,500	3.31	$620,100
Plan 2				
200' Berm	$725,800	$103,500	7.01	$622,300
225' Berm	$796,500	$169,000	4.71	$627,500
250' Berm	$897,500	$269,000	3.34	$628,500
Plan 3				
200' Berm	$734,800	$ 95,000	7.73	$639,800
225' Berm	$805,500	$153,000	5.26	$652,500
250' Berm	$906,500	$236,000	3.84	$670,500
Plan 4	$ 4,000	$ 10,700	0.37	0

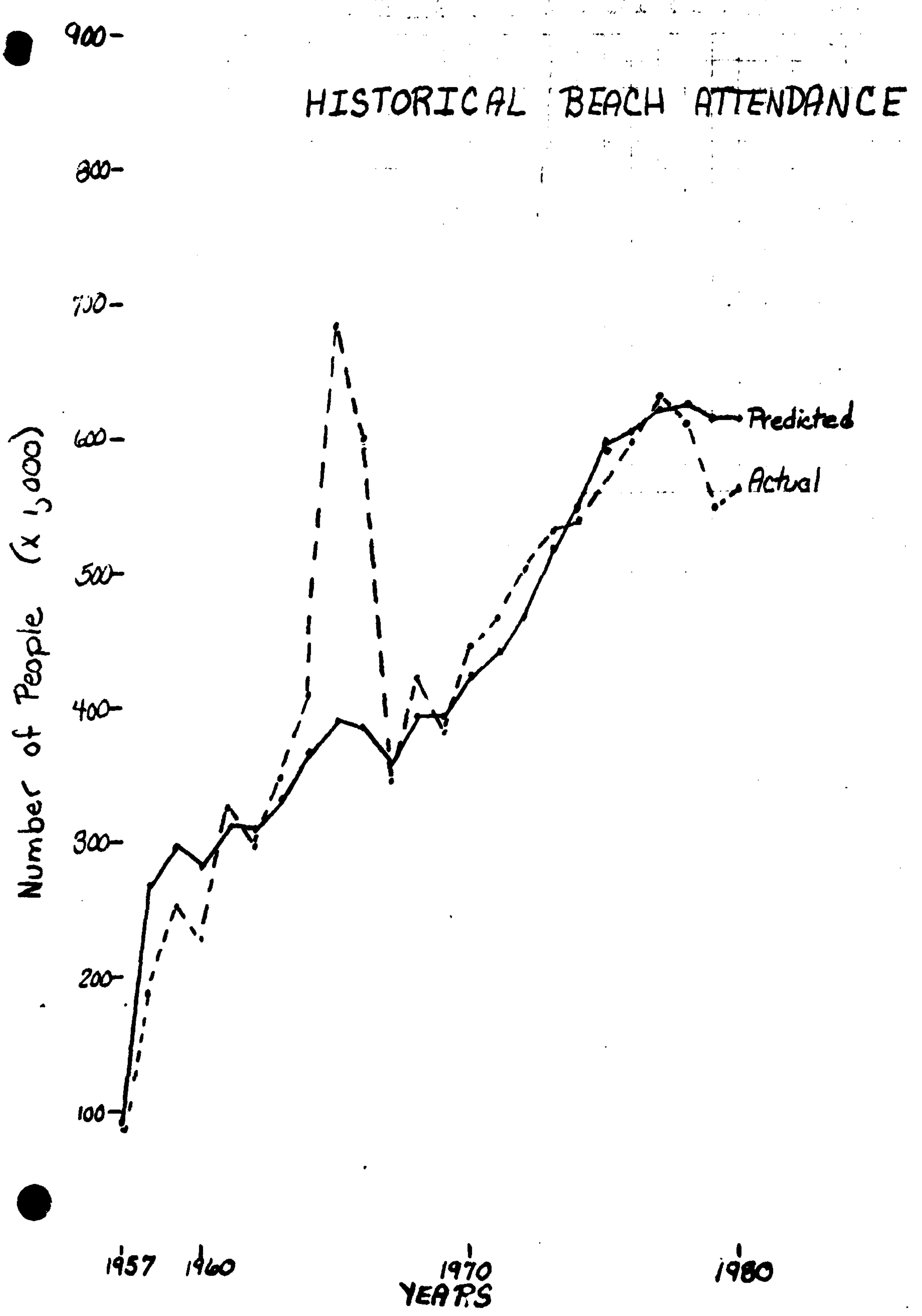
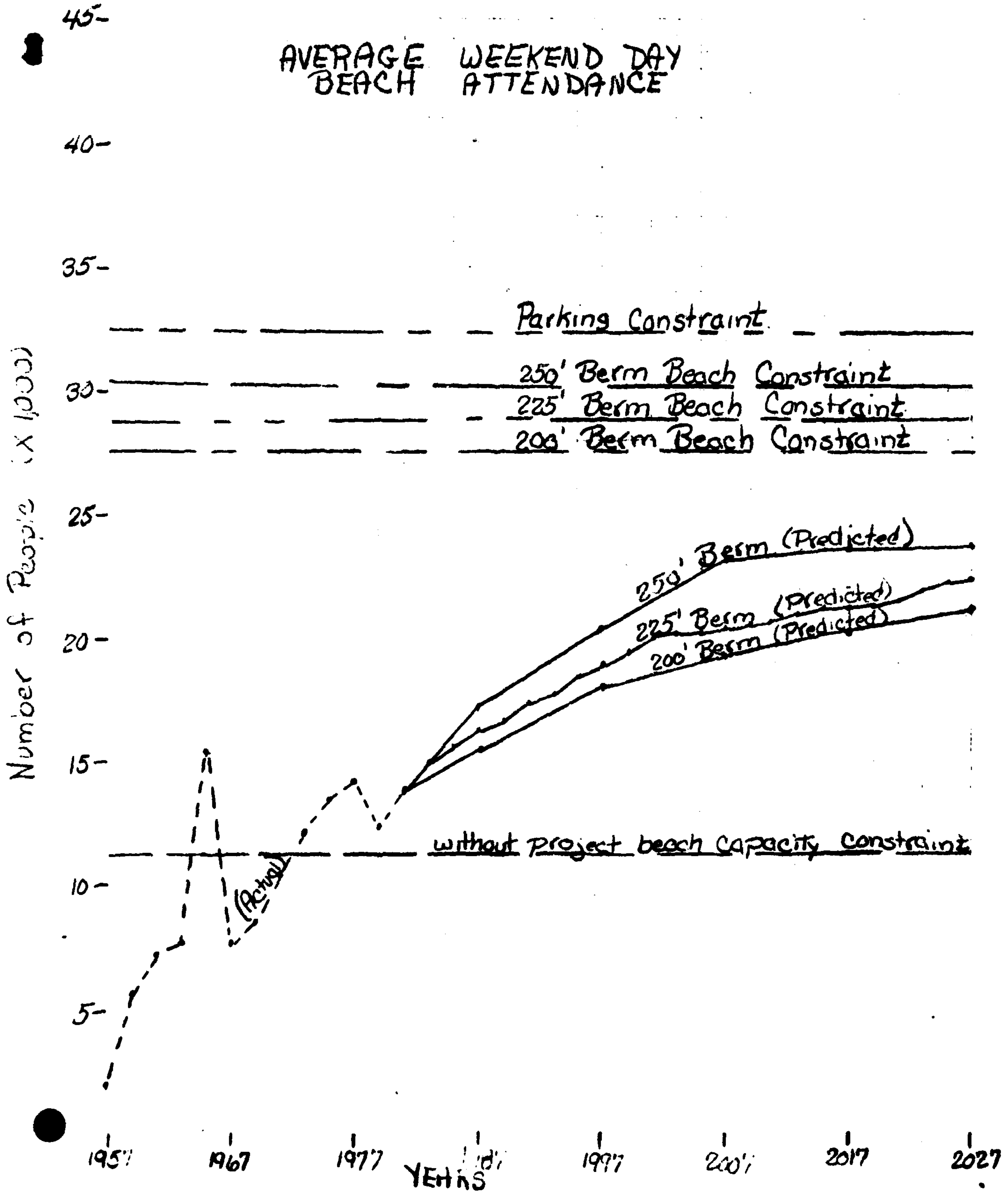

HISTORICAL BEACH ATTENDANCE
900
800
700
600
500
400
300
200
100
Number of People (x 1,000)
Predicted
Actual
1957
1960
1970
1980
YEARS

Figure 8-1



AVERAGE WEEKEND DAY
BEACH ATTENDANCE
45
40
35
30
25
20
15
10
5
Number of People (X 1000)
Parking Constraint
250' Berm Beach Constraint
225' Berm Beach Constraint
200' Berm Beach Constraint
250' Berm (Predicted)
225' Berm (Predicted)
200' Berm (Predicted)
(Actual)
without project beach capacity constraint
1957
1967
1977
1997
2017
2027
YEARS

FIGURE 8-2

APPENDIX 9

RECONNAISSANCE REPORT

RECONNAISSANCE REPORT
BEACH EROSION CONTROL STUDY FOR
SHERWOOD ISLAND STATE PARK, WESTPORT, CONNECTICUT

1. Description and Prior Report. Sherwood Island State Park is located in Westport, Connecticut, approximately ten miles west of Bridgeport, Connecticut, and fifty miles east of New York City. An authorized beach erosion control improvement was developed and constructed by the State of Connecticut in 1957 at a total cost of $559,632. The Federal share of this project was $186,300. This initial project consisted of widening to a 150-foot width, 6000 feet of the beach by direct placement of sand and the creation of a stockpile by the direct placement of sand to an additional width of 100 feet for a distance of 1000 feet east and 1000 feet west of Sherwood Point. Also included was the construction of two impermeable training walls 400 and 500 feet long at Burial Hill Creek and the construction of an impermeable groin 500 feet long at the western extremity of the improvement. Upon completion of the project, rapid deterioration of the beach began to appear. In a letter dated 23 September 1966, the State of Connecticut reported that the material from the stockpile of sand, that was centrally placed at 100 feet each side of the point, apparently drifted rapidly by the adjacent beaches, thereby exposing the point to further erosion. As a result, the Committee on Public Works of the United States Senate on 15 May 1968 adopted a resolution which reads in part; "with a view to determining whether any modifications on the recommendations contained therein are advisable at the present time, in the interest of beach erosion control and allied purposes, at and in the vicinity of Sherwood Island State Park, Westport, Connecticut".

As a result of this resolution, a study was completed in November 1974. The report recommended that a modification of the existing project be adopted and recommended that in lieu of the project authorized in 1950, that a new plan of improvement be adopted. The revised plan of improvement consisted of beach widening by direct placement of suitable sandfill to furnish a dry beach width of approximately 325 feet above the mean high water line for a distance of 3000 feet west on the existing timber training wall and for a distance of 1800 feet east of the existing stone groin structure. In addition to beach widening, a system of three stone groins would be provided. One groin, 485 feet long, located 600 feet east of the point, and a second groin, also 485 feet long, to be located about 600 feet west of the point. The third groin, a 400-foot long low-profile structure, would be located approximately 1100 feet west of the point. Also, 1200 feet of the point would be revetted and the inner 225 feet on the existing westerly groin structure would be raised from elevation 12.0 to 13.0 feet above mean low water (see location map).

The estimated cost of construction of the project was $3,413,000 with the Federal share of the cost construction being $2,389,000 and the nonfederal share was $1,024,000. The benefit-cost ratio was 4.6 to 1.0.

The report was completed in November 1974 and forwarded to the Board of Engineers for Rivers & Harbors for approval. At that time the cost sharing was divided 70 percent Federal and 30 percent non-Federal. The project engineer at the Board reviewing the report notified the New England Division that he would not allow Federal participation in the cost of sandfill that excluded the 1957 mean high water line. As a result of this decision the state was notified of the change in cost sharing and in a letter (inclosed), dated 5 February 1975, from Mr. William Miller, Chief Parks and Recreation Unit, he stated that the state was unable to commit to the increase in funding as suggested by the Board. The report was recalled and never officially acted upon by the Board.

Since the report was returned, the state has at its own expense completed work to improve the condition of the beach and retard the erosion and overtopping of backshore at Sherwood Point. Random fill and spoil material was dumped at Sherwood Point. The point was extended approximately 200 feet and the existing west groin structure was raised. As a result of this effort, the need for the improvement as suggested in the 1974 report is reduced considerably. The work proposed along the east beach is no longer necessary. The two groin structures at the point can be eliminated. Therefore, the only work necessary at this time is the placement of sandfill and the construction of a low profile groin structure on the west beach. A preliminary cost estimate indicates that the total first cost of construction would be $1,090,800 - of which $763,560 would be the Federal share and $327,240 the non-Federal share.

2. Economic Analysis. Based on the data from the 1974 report and a general knowledge of the popularity of the beach and the recreational use requirements for this area, the demand far exceeds the supply. Economic studies will be developed to determine if the proposed beach plan will satisfy the projected demand. Based on the 1974 report the estimated benefits derived for the west beach are $487,500.

3. Estimate of First Cost. The plan of improvement considered for this report is based on the 1974 Corps of Engineers completed report and consists of beach widening by the direct placement of suitable sandfill, one low profile groin structure, and revetment along Sherwood Point to stabilize the point. Also considered is rock revetment in lieu of sandfill to protect the backshore and shoreline structures. The first cost is based on January 1980 price levels and 50-year life of the project.

PLAN 1 - Beach widening by the direct placement of suitable sandfill to furnish a dry beach width of approximately 325 feet above the mean high water line along approximately 1800 feet of beach east of the existing stone groin structure. In addition, the construction of one low-profile groin structure and rock revetment along Sherwood Point.

PLAN 2 - Rock revetment along the entire 1800 feet of backshore to protect and prevent further erosion of the shoreline.

FIRST COST

PLAN 1

Groin (stone, low-profile)	2200.0 tons @ $30.00	$ 66,000
Sandfill	115,000 yd^3 @ $ 5.50	632,500
Revetment (point)	4000 tons @ $30.0	120,000
	Subtotal	$ 818,500
Contingencies		163,500
	Subtotal	$ 982,000
Engineering & Design		98,000
	Subtotal	$1,080,000
Supervision & Administration		10,800
	TOTAL FIRST COST	$1,090,800

Federal Share of Cost (70%)	$763,560
Non-Federal Share of Cost (30%)	$327,240

PLAN 2

Groin	30,000 tons @ $30.00	$ 900,000
Excavation	L.S.	25,000
Revetment (point)	4000 tons @ $30.00	120,000
	Subtotal	$1,045,000
Contingencies		205,000
	Subtotal	$1,250,000
Engineering and Design		125,000
	Subtotal	$1,375,000
Supervision and Administration		125,000
	TOTAL FIRST COST	$1,500,000

This minimum plan of protection, designed to protect the west beach, is estimated to cost $1,500,000. This plan will provide a backshore revetment between the existing west groin structure and Sherwood Point and revetment of the point to prevent flanking. This minimum protection will provide no recreational benefits and only $10,000 in damage prevention benefits. This plan is not economically justified for Federal participation.

4. Apportionment of Cost. The first cost of construction of the proposed beach improvement will be proportioned between Federal and non-Federal interests. This cost will be shared 70 percent Federal and 30 percent non-Federal.

5. Estimate of Annual Charges. Annual charges are based on January 1980 price levels, 50-year life of project and an interest rate of 7⅛ percent for both Federal and non-Federal charges.

ANNUAL CHARGES

PLAN 1

Federal

Interest	0.07125 x $763,560	$ 54,403
Amortization	0.00235 x $763,560	17,944
Periodic Nourishment	7300 cy @ $7.00	51,100
	TOTAL FEDERAL COST	$123,447

Non-Federal		
Interest	0.07125 x $327,240	$ 23,316
Amortization	0.00235 x $327,240	7,690
Periodic Nourishment	3100 cy @ $7.00	21,700
Maintenance		
Groins	100 tons @ $35.00	3,500
Revetment	200 tons @ $35.00	7,000
	TOTAL NONFEDERAL COST	$63,206
	TOTAL ANNUAL COST	$186,653

6. Comparison of Benefits and Costs. The following is a brief summary of the benefits and costs for the two plans.

	Annual Benefits	Annual Costs	B/C Ratio
PLAN 1	$487,500	$186,653	2.6
PLAN 2	10,000	(No Federal participation)	

7. Local Cooperation. The proposed project would require that the first cost of the project be borne 70 percent by the United States and 30 percent by the State of Connecticut. This cost would include the cost of periodic sand nourishment for the economic life of the project. Beach erosion regulations require that Federal participation in a beach project under Section 103 is subject to the conditions that local interests agree to:

a. Contribute prior to construction, in cash, 30 percent of the first cost of construction; final apportionment of cost will be made after actual costs and values have been determined.

b. Assume full responsibility for all project costs in excess of the Federal limitation of $1,000,000.

c. Maintain continued public ownership of the park and shore and its administration for public use during the 50-year economic life of the project by establishing, prior to construction, a boundary control line which will separate public property from private property use, for the realization of the public benefits upon which Federal participation is based.

d. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for project construction and subsequent maintenance of the project.

e. Hold and save the United States free from all claims for damages that may arise before, during, or after prosecution of the work and subsequent maintenance of the project other than damages due to the fault or negligence of the United States or its contractors.

f. Maintain the protective measures during the economic life of the project as may be required to serve their intended purpose by contributing, in cash, 100 percent of the cost of groin maintenance and 50 percent of the cost of periodic sand nourishment for the 50-year life of the project; such contribution is to be made prior to each nourishment operation.

g. Control water pollution to the extent necessary to safeguard the health of the bathers.

h. Comply with the requirements of non-Federal cooperation specified in Section 210 and 305 of Public Law 91-646, approved 2 January 1971, entitled, "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

i. Comply with Title VI of the Civil Rights Act of 1964 (78 Stat 241) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

8. Conclusions. The Division Engineer concludes that the erosion and redistribution of beach sand along west beach at Sherwood Island State Park Beach is causing rapid deterioration of the beach and the beach is essential to the State of Connecticut. He also concludes that further detailed study should be undertaken for developing a method of construction to provide a more stable beach for the long range needs of the area. He also concludes that the study will consider alternative methods of providing the most practical, economical and environmentally accepted method of correcting the problem. The study will consider the national and planning objectives or goals, and the accounts encompassed by the Principles and Standards will reflect the total environment as set forth in the National Environmental Policy Act of 1969 and the Water Resources Planning Act enacted by Congress in 1965 as supplemented and amended.

9. Recommendations. The Division Engineer recommends that a detailed beach erosion control project report be proposed to determine the most environmental, economical and practical beach erosion control improvement for Sherwood Island State Park Beach. The Division Engineer further recommends that the study be undertaken pursuant to the Small Beach Erosion Control Project Authority provided by Section 103 of the 1962 River and Harbor Act.

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OFFICE BUILDING HARTFORD, CONNECTICUT 06115

February 5, 1975

Colonel John H. Mason (Attention NEDPL-C)
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Mason:

This is in reply to your letter of January 29, 1975. Regarding the change in the percentage of cost sharing of the Sherwood Island State Park beach erosion control report dated November 1974 by your Coastal Development Branch - this project maintains a high priority in our development program for State Parks in Connecticut.

However, as you know, at this time the economic climate in Connecticut is less than desirable to promote a program of this magnitude. We cannot, therefore, at this time commit to this increase in funding which was necessitated by the Board of Engineers for rivers and harbors in their review of the Sherwood Island Report. We would like to think that any preparations by the Corp could proceed so that preliminaries would be accomplished in the event we were able to commit ourselves for funding in 1976-77. In any event, if we cannot proceed, we would not like to see this project dropped, but consideration given to placing it in a "hold" position with the thought that we could reactivate it in a moment's notice at a future date.

If indeed a meeting would serve us better so that we could discuss any alternative plans, we will be more than happy to submit to this and would leave this up to you or, if you so desire, to Mr. Bruha.

Very truly yours,

W. F. Miller

William F. Miller
Chief
Parks and Recreation Unit

WFM:n

(Tel. Hartford...566-2304)

Appendix 9
9-6

I called Mr. Miller ... 75 ... the letter. He said the ... No money to participate in this project ... of the ... TCB

ELLA GRASSO
GOVERNOR

STATE OF CONNECTICUT
EXECUTIVE CHAMBERS
HARTFORD

January 19, 1979

Colonel John P. Chandler
U. S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Chandler:

In earlier correspondence I have requested the Corps' assistance in the development of Silver Sands State Park in Milford, Connecticut.

I have been informed by Commissioner Stanley J. Pac of the Department of Environmental Protection that as a part of the state's ongoing program of beach improvements, it would be desirable to complete the shore erosion project at Sherwood Island State Park in the Town of Westport. I am, therefore, requesting the Corps' assistance to bring this project to a conclusion.

It has been my intention since assuming office to provide the citizens of Connecticut the best possible shore line facilities for recreational purposes. The stabilization of the beach at Sherwood Island and the development of Silver Sands State Park represent a substantial achievement toward this objective.

Commissioner Pac is responsible for the overall project and it is my understanding that the project officer for the beach development will be Richard Clifford of the DEP's Park and Recreation Unit. Mr. Clifford can be reached at (203) 566-2304.

I wish to thank you for your interest in this project and look forward to cooperatively bringing it to a successful conclusion.

With best wishes,

Cordially,

Ella

ELLA GRASSO
Governor

Appendix 9
9-7

It was good of you to come to our meeting and help with the N.H.-Stamford problem - EG

APPENDIX 10

GLOSSARY OF TERMS

GLOSSARY OF TERMS

ACCRETION - A buildup of land which may be either natural or artificial. Natural accretion is the buildup of land, solely by the forces of nature, on a BEACH by deposition of waterborne or airborne material. Artificial accretion is a similar buildup of land by an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

ADVANCE (OF A BEACH) - (1) A continuing seaward movement of the shoreline. (2) A net seaward movement of the shoreline over a specified time.

ALONGSHORE - Parallel to and near the shoreline; same as LONGSHORE.

AMPLITUDE, WAVE - The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from stillwater level to wave crest. For a sinusoidal wave, amplitude is one-half the wave height.

AQUIFER - Stratum or zone below the surface of the earth capable of producing water.

ARTIFICIAL NOURISHMENT - The process of replenishing a beach with material (usually sand) obtained from another location.

AWASH - Situated so that the top is intermittently washed by waves or tidal action. Condition of being exposed or just bare at any stage of the tide between high water and chart datum.

BACKSHORE - The zone of a shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water. It comprises the BERM or BERMS. (See Figure 10-1 located at the end of glossary.)

BACKWASH - (1) The seaward return of the water following the uprush of the waves. (2) Water or waves thrown back by an obstruction such as a ship, breakwater or cliff.

BANK - (1) The rising ground bordering a lake, river or sea; the face of a scarp. (2) An elevation of the sea floor of large area, located on a continental (or island) shelf and over which the depth is relatively shallow but sufficient for safe surface navigation; a group of shoals. (3) In its secondary sense, a shallow area consisting of shifting forms of silt, sand, mud and gravel, but in this case it is only used with a qualifying word such as "sandbank" or "gravelbank".

BAR - A submerged or emerged embankment of sand, gravel or other unconsolidated material built on the sea floor in shallow water by waves and currents, especially at the mouth of a river or estuary or lying a short distance from, and usually parallel to, the beach. See BAYMOUTH BAR.

BARRIER BEACH - A bar essentially parallel to the shore, the crest of which is above normal high water level.

BASEMENT - Rock complex, generally of IGNEOUS and METAMORPHIC rocks, overlain UNCONFORMABLY by SEDIMENTARY strata.

BATHYMETRY - The measurement of depths of water in oceans, seas and lakes; also information derived from such measurements.

BAY - A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf but larger than a cove.

BAYMOUTH BAR - A bar extending partly or entirely across the mouth of a bay.

BEACH - A zone of unconsolidated material that extends landward from the low-water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach - unless otherwise specified - is the mean low-water line. A beach includes FORESHORE and BACKSHORE. (See Figure 10-1.)

BEACH BERM - A flat terrace located at the top of the foreshore. Also, a nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several. (See figure 10-1.)

BEACH WIDTH - The horizontal dimension of the beach measured perpendicular to the shoreline.

BED - The smallest division of a stratified series, marked by a more or less well-defined divisional plane from its neighbors above and below.

BED FORMS - Any deviation from a flat bed that is readily detectable by eye, and higher than the largest sediment size present in the parent bed material; generated on the bed of an alluvial channel by the flow.

BEDROCK - Any solid rock exposed at the surface of the earth or overlaid with unconsolidated material.

BERM CREST - The seaward limit of a berm. (See Figure 10-1.)

BLOWOUT - A general term for various saucer-, cup- or trough-shaped hollows formed by wind erosion on a preexisting dune or other sand deposit.

BLUFF - Any high headland or bank presenting a precipitous front.

BOTTOM - The ground or bed under any body of water; the bottom of the sea. (See Figure 10-1.)

BOULDER - A rounded rock more than 10 inches in diameter.

BREAKER - A wave breaking on a shore.

BREAKWATER - A structure protecting a shore area, harbor, anchorage or basin from waves.

CHANNEL - (1) The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. (2) The deepest part of a stream, bay or strait though which the main volume or current of water flows.

CHART DATUM - The plane or level to which soundings (or elevations) or tide heights are referenced. The surface is called a tidal datum when referred to a certain phase of tide. See also DATUM PLANE.

CLASTIC - Consisting of fragments of rocks or of organic structures that have been moved individually from their place of origin.

CLAY - Fine-grained soil consisting of organic material the grains of which have diameters smaller than 0.005 millimeters. Finer than SILT.

CLIFF - A high, steep face of rock; a precipice. See also MARINE CLIFF and SEA CLIFF.

COAST - A strip of land of indefinite width (may be several miles) that extends from the shoreline inland to the first major change in terrain features. (See Figure 10-1.)

COASTAL AREA - The land and sea area bordering the shoreline. (See Figure 10-1.)

COASTAL PLAIN - A plain composed of horizontal or gently sloping strata of CLASTIC materials fronting the coast.

COASTLINE - (1) Technically, the line that forms the boundary between the COAST and the SHORE. (2) Commonly, the line that forms the boundary between the land and the water.

COBBLE - A rock fragment between 65 and 256 millimeters in diameter, thus larger than a PEBBLE and smaller than a BOULDER, rounded or otherwise abraded in the course of aquenous, eolian or glacial transport.

CONTINENTAL SHELF - The zone bordering a continent and extending from the low-water line to the depth (usually about 100 fathoms) where there is a marked or rather steep descent toward a greater depth.

CONTOUR - A line on a map or chart representing points of equal elevation with relation to a datum.

CONVERGENCE - (1) In refraction phenomena, the decreasing of the distance between ORTHOGONALS in the direction of wave travel. Denotes an area of increasing wave height and energy concentration. Also FOCUSING. (2) In wind-setup phenomena, the increase in setup observed over that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth; also the decrease in basin width or depth causing such increase in setup.

COVE - A small, sheltered recess in a coast, often inside a larger embayment.

CREEP - Movement of an individual sand grain as a result of being hit by a windborne sand grain.

CREST OF WAVE - (1) The highest part of a wave. (2) That part of the wave above stillwater level. (See Figure 10-2 located at the end of the glossary.)

CROSSBEDDING - The arrangement of laminations of strata transverse or oblique to the main planes of stratification of the strata concerned; inclined, often lens-shaped beds between the main bedding planes.

CRYSTALLINE - An inexact general term for igneous or metamorphic rocks as opposed to sedimentary rocks.

CULM - STEM of grasses, usually hollow except at the swollen NODES.

CULTURAL EROSION - Erosion caused by effects of man's actions on the land-excavation, traffic (vehicular and foot) and construction (inland and shoreline).

CURRENT - A flow of water due to surface gradient, tidal phenomena, winds and/or differential atmospheric pressures. See EBB CURRENT, FLOOD CURRENT, LITTORAL CURRENT, LONGSHORE CURRENT, AND FIDAL CURRENT.

CURRENT RIPPLE - A ripple mark produced by the action of a current flowing steadily in one direction over a bed of sand. See also RIPPLES (BED FORMS).

CYCLONE - In the northern hemisphere, a storm characterized by strong winds rotating counterclockwise about a center of low atmospheric pressure.

DATUM PLANE - The horizontal plane to which soundings, ground elevations or water surface elevations are referred. Also REFERENCE PLANE. The plane is called a TIDAL DATUM when defined by a certain phase of the tide. On the Atlantic coast of the United States MEAN LOW WATER is the datum ordinarily used on hydrographic charts. A common datum used on topographic maps is based on MEAN SEA LEVEL.

DEEP WATER - Water so deep that surface waves are little affected by the ocean bottom. Generally, water deeper than one-half the surface wave-length is considered deep water.

DEFLATION - The removal of loose material from a beach or other land surface by wind action.

DEFOCUSING - The spreading farther apart of wave rays in shallow water than in deep water; height or amplitude of the breaking wave is less than at points where no defocusing occurs. See also DIVERGENCE.

DEGLACIATION - The uncovering of an area from beneath glacier ice as a result of shrinkage of a glacier.

DELTA - An alluvial deposit, roughly triangular or digitate in shape, formed at a river mouth.

DENUDATION - The stripping of forests and vegetation from the land.

DEPTH - The vertical distance from a specified tidal datum to the sea floor.

DISCOID - Having the form of a disk.

DIVERGENCE - (1) In refraction phenomena, the increasing of distance between ORTHOGONALS in the direction of wave travel. Denotes an area of decreasing wave height and energy concentration. Also DEFOCUSING. (2) In WIND-SETUP phenomena, the decrease in setup observed under that which would occur in an equivalent rectangular basin of uniform depth, caused by changes in planform or depth. Also the increase in basin width or depth causing such decrease in setup.

DOWNDRIFT - The direction of predominant movement of littoral materials.

DRIFT (noun) - (1) Sometimes used as a short form for LITTORAL DRIFT. (2) The speed at which a current runs. (3) Also floating material deposited on a beach (driftwood). (4) A deposit of a continental ice sheet, as a drumlin. See GLACIAL DRIFT

DRIFT DEPOSIT - Any accumulation of glacial origin; glacial or glaciofluvial deposit.

DUNE - Ridge or mound of loose, windblown material, usually sand.

EBB CURRENT - The tidal current away from shore or down a tidal stream; usually associated with the decrease in the height of the tide.

EBB TIDE - The period of tide between high water and the succeeding low water; a falling tide.

EMBAYMENT - An indentation in the shoreline forming an open bay.

EOLIAN SANDS - Sediments of sand size or smaller which have been transported by winds. They may be recognized in marine deposits off desert coast by the greater angularity of the grains compared with waterborne particles.

EQUATORIAL TIDES - Consecutive tides with similar ranges occurring when the moon's orbit is on or close to the equator; morning and afternoon tides are very much alike.

EROSION - The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

EYE - In meteorology, usually the "eye of the storm" (hurricane); the roughly circular area of comparatively light winds and fair weather found at the center of a severe tropical cyclone.

EUSTATIC - Pertaining to simultaneous, world-wide changes in sea level; also related to the amount of water incorporated in ice caps.

EUTROPHICATION - Process occurring in a lake making it rich in dissolved nutrients, but dificient in oxygen.

FAN - An accumulation of debris brought down by a stream descending a steep ravine and debouching in the plain beneath, where the detrital material spreads out in the shape of a fan.

FATHOM - A unit of measurement used for soundings. It is equal to 6 feet (1.83 meters).

FETCH - The continuous area of open water over which the wind blows in a constant direction. In enclosed bodies of water, it would ususally coincide with the longest axis in the general wind direction. Sometimes used synonymously with FETCH LENGTH.

FETCH LENGTH - The horizontal distance (in the direction of the wind) over which the wind blows to generate SEAS or create a WIND SETUP.

FLOOD CURRENT - The tidal current toward shore, usually associated with the increase in the height of the tide.

FLOOD PLAIN - That portion of a river valley, adjacent to the river channel, that is built of sediments during the present regiment of the stream and that is covered with water when the river overflows its banks at flood stages.

FLOOD TIDE - The period of tide between low water and the succeeding high water; a rising tide.

FLUVIAL - Of or pertaining to rivers; produced by river action, as a fluvial plain.

FOCUSING - The closing together of wave rays in shallow water; height of breaking wave is greater than at points where there is no focusing. See also CONVERGENCE

FOREDUNE - The front dune immediately behind the backshore.

FORESHORE - The part of the shore lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the orinary low-water mark that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall. (See Figure 10-1.)

FOSSIL - The remains or traces of animals or plants that have been preserved by natural causes in the earth's crust exclusive of organisms that have been buried since the beginning of historic time.

FOSSILIFEROUS - Containing organic remains.

FRONTAL MARGIN - The leading edge of a glacier.

FULCRUM POINT - Point at which there is no net erosion or accretion; erosion occurs on one side of the fulcrum point, accretion on the other.

GALE - Continuous winds with velocities in excess of 32 miles per hour.

GENERATION OF WAVES - (1) The creation of waves by natural or mechanical means. (2) The creation and growth of waves caused by a wind blowing over a water surface for a certain period of time.

GLACIAL - Pertaining to, characteristic of, produced or deposited by or derived from a glacier.

GLACIAL DRIFT - Sediment (a) in transport in glaciers, (b) deposited by glaciers, and (c) predominantly of glacial origin, made in the sea or in bodies of glacial meltwater. See DRIFT.

GLACIATION - Alteration of the earth's solid surface through erosion and deposition by glacier ice.

GLACIER - A mass of ice with definite lateral limits, with motion in a definite direction and originating from the compacting of snow by pressure.

GLACIO- -A combining form frequently used with other words to denote formation by or relationship to glaciers.

GLACIOFLUVIAL - Pertaining to streams flowing from glaciers or to the deposits made by such streams.

GLACIOLACUSTRINE - Produced by or belonging to glacial lakes.

GRADIENT (GRADE) - With reference to winds or currents, the rate of increase or decrease in speed, usually in the vertical; or the curve that represents this rate. The change in a variable quantity, as temperature, per unit distance.

GRANITE - Loosely used for any light-colored, coarse-grained igneous rock. Actually an igneous rock consisting of essentially alkalic feldspar and quartz.

GRANITIC - Pertaining to or composed of granite or granite-like rock.

GRAVEL - Accumulation of rounded, waterworn PEBBLES. The word gravel is generally applied when the size of the pebbles does not much exceed that of an ordinary hen's egg; fragment size ranges from 76 to 4.76 millimeters; may or may not contain interstitial sand ranging from 50 to 70 percent of the total mass.

GROIN - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore. Groins are usually constructed of rock, timber, or sheet piles. See LOW PROFILE GROIN and TERMINAL GROIN.

GROIN SYSTEM - A series of groins acting together to protect a section of beach. Commonly called a groin field.

GROUNDWATER - Subsurface water occupying the zone of saturation. In a strict sense, the term is applied only to water below the WATER TABLE.

GULF - A large embayment in a coast; the entrance is generally wider than the length.

HANGING VALLEY - A tributary valley whose floor is higher than the floor in the area of intersection.

HARBOR - Any protected water area affording a place of safety for vessels.

HEADLAND (HEAD) - A high, steep-faced promontory extending into the sea.

HIGH TIDE, HIGH WATER (HW) - The maximum elevation reached by each rising tide. See TIDE.

HIGH-WATER MARK - In the strict sense, the intersection of the plane of mean high water with the shore. The shoreline delineated on the nautical charts of the U.S Coast and Geodetic Survey is an approximation of the high-water line. For specific occurrences, the highest elevation on the shore reached during a storm or riding tide, including meteorological effects.

HOLLOW - A small ravine; a low tract of land encompassed by hills.

HOOK - A spit or norrow cape of sand or gravel which turns landward at the outer end.

HURRICANE - An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. TROPICAL STORM is the term applied if maximum winds are less than 75 miles per hour.

HURRICANE PATH OR TRACK - Line of movement (propagation) of the eye through an area.

HYDROLOGY - The science that relates to the water of the earth.

IGNEOUS - Formed by solidification from a molten or partially molten state.

INLET - (1) A short, narrow waterway connecting a bay, lagoon or similar body of water with a large parent body of water. (2) An arm of the sea (or other body of water) that is long compared to its width and that may extend a considerable distance inland.

IN-MIGRATION - The net increase in population due to an excess of people moving in over people moving out.

INSHORE (ZONE) - The zone of variable width extending from the low-water line through the breaker zone. (See Figure 10-1.)

JETTY - On open seacoasts, a structure extending into a body of water and designed to prevent shoaling of a channel by littoral materials and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel.

KAME - A conical hill or short irregular ridge of gravel or sand deposited in contact with glacial ice.

KETTLE - A pit or depression in drift made by the wasting away of a detached mass of glacier ice that had been either wholly or partly buried in the drift.

KINETIC ENERGY (OF WAVES) - In a progressive oscillatory wave, a summation of the energy of motion of the particles within the wave.

KNOT - The unit of speed used in navigation. It is equal to 1 nautical mile (6,076,115 feet or 1,852 meters) per hour; about 1.15 statute miles per hour.

LAGOON - A shallow body of water, as a pond or lake, usually connected to the sea.

LANDFILL - A system of trash and garbage disposal in which the waste is buried between layers of earth.

LEACHATE - Highly concentrated effluent resulting from the leaching of landfills.

LEE - Shelter, or the part sheltered (or turned away) from the wind or waves.

LENGTH OF WAVE - The horizontal distance between similar points on two successive waves measured perpendicularly to the crest (See Figure 10-2.)

LIFT - A section of sand or snow fence designed to catch and hold windblown sand to increase the height of a dune.

LITHOLOGY - The physical character of a rock, generally determined megascopically or with the aid of a low-power magnifier.

LITTORAL - Of or pertaining to a shore, especially of the sea.

LITTORAL CURRENT - Any current in the littoral zone caused primarily by wave action, e.g., longshore current, rip current.

LITTORAL DEPOSITS - Deposits of littoral drift.

LITTORAL DRIFT - The sedimentary material moved in the littoral zone under the influence of waves and currents.

LITTORAL TRANSPORT - The movement of littoral drift in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (onshore and offshore transport) to the shore.

LITTORAL TRANSPORT RATE - Rate of transport of sedimentary material parallel or perpendicular to the shore in the littoral zone. Usually expressed in cubic yards (meters) per year. Commonly used as synonymous with LONGSHORE TRANSPORT RATE.

LITTORAL ZONE - An indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

LOBE - A projection of a glacial margin or of a body of glacial drift beyond the main mass of ice or drift.

LONGSHORE - Parallel to and near the shoreline.

LONGSHORE CURENT - The littoral current in the breaker zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

LONGSHORE ENERGY FLUX - It is equal to the component of wave energy flux per unit length of shoreline which is parallel to the shoreline. See WAVE ENERGY FLUX.

LONGSHORE TRANSPORT - The movement of sedimentary material parallel to the shore. The rate of longshore transport is usually expressed in cubic yards (meters) per year. Commonly used as synonymous with LITTORAL TRANSPORT.

LOW PASS FILTER - A device (electronic or digital) that attenuates the higher frequency components of a signal but that leaves the amplitude of the lower frequency components unaffected.

LOW PROFILE GROIN - A groin placed (usually midway along the proposed project) at or just below the proposed or existing ground. See GROIN.

LOW TIDE (LOW WATER, LW) - The minimum elevation reached by each falling tide. See TIDE.

LOW-WATER MARK - The intersection of any standard low tide datum plane with the shore.

MARINE CLIFF - A cliff, sometimes composed of unconsolidated sediments, facing the ocean and formed by wave action.

MARSH - An area of soft, wet or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

MASS TRANSPORT - The net transfer of water by wave action in the direction of wave travel. See ORBIT.

MEAN HIGH WATER (MHW) - The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

MEAN LOW WATER (MLW) - The average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value.

MEAN SEA LEVEL - The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings.

MELT WATER - Water resulting from the melting of snow or of glacial ice.

METAMORPHIC ROCK - Includes all those rocks that have formed in the solid state in response to pronounced changes of temperature, pressure and chemical environment, which generally take place below the zones of weathering and cementation.

MIGRATE - To translocate (as a dune, spit or inlet, more or less as a unit) under the continued action of wind, waves and currents.

MORAINE - Drift deposited chiefly by direct glacial action and having constructional topography independent of control by the surface on which the drift lies.

MORPHOLOGY - The observation of the form of lands.

MUD - A fluid-to-plastic mixture of finely divided particles of solid material and water.

MUD FLAT - An accumulation of mud that is exposed at low tide and covered by shallow water at high tide.

NAUTICAL MILE - Generally 1 minute of latitude is considered equal to 1 nautical mile. The accepted United States value as of 1 July 1959 is 6,076.115 feet or 1,852 meters, approximately 1.15 times as long as the statute mile of 5,280 feet. Also geographical mile.

NEAP TIDE - A tide occurring near the time of quadrature of the moon with the sun. The neap tidal rage is usually 10 to 30 percent less than the mean tidal range.

NEARSHORE (ZONE) - An indefinite zone extending seaward from the shoreline well beyond the breaker zone. (See Figure 10-1.)

NODAL POINT - The point where the predominant direction of the LONGSHORE TRANSPORT changes. The point at which the longshore current of sediment transport changes sign.

NODE - Joint of a STEM where a leaf is borne or may be borne. Buds are also commonly borne at the node.

NORTHEASTER - Any east coast storm (except a hurricane) of the middle Atlantic and New England States that produces strong onshore winds.

NOURISHMENT - The process of replenishing a beach. It may be brought about naturally by longshore transport or artificially by the deposition of dredged materials.

NUTRIENT - A nutritive substance or ingredient, referring here to organic nutrients in the soil and underlying sediments both above and in the water table.

OFFSHORE - (1) The comparatively flat zone of variable width, extending from the breaker zone to the seaward edge of the Continental Shelf. (2) A direction seaward from the shore. (See Figure 10-1.)

OFFSHORE WIND - A wind blowing from land to sea in the coastal area.

ONSHORE - A direction from sea to land.

ONSHORE WIND - A wind blowing from sea to land in the coastal area.

ORBIT - In water waves, the path of a water particle affected by the wave motion. In deep-water waves the orbit is nearly circular and in shallow-water waves the orbit is nearly elliptical. In general, the orbits are slightly open in the direction of wave motion giving rise to MASS TRANSPORT.

ORTHOGONALS - On a wave-refraction diagram, a line drawn perpendicular to the wave crests. Also WAVE RAY.

OUTFALL - A structure extending into a body of water for the purpose of discharging sewage, storm runoff or cooling water.

OUTWASH - Materials deposited by meltwater streams beyond active glacier ice.

OUTWASH PLAIN - Fan-shaped overlapping deltas deposited by streams flowing from the glacier.

OVERTOPPING - Passing of water over the top of a structure as a result of wave runup or surge action.

PAMET - An outwash channel carved in glacial drift and having irregularities resulting from melting of blocks of stagnant ice.

PAMET SAG - Depression in the edge of the scarp caused by its intersection by a pamet.

PARABOLIC DUNE - A dune having (in ground plan) approximately the form of a parabola, with the concave side toward the wind.

PEAT - A dark-brown or black residuum produced by the partial decomposition of various plants (mosses, trees, etc.) that grow in marshes and similar wet places.

PEBBLES - Smooth rounded stones ranging in diameter from 2 to 64 millimeters.

PHASE SHIFT - A shift to the right of a sine wave.

PHI GRADE SCALE - A logarithmic transformation of the Wentworth grade scale for size classification of sediment grains based on the negative logarithm to the base 2 of the particle diameter. Measured in Phi units.

PITTED OUTWASH PLAIN - An outwash plain of gravel or sand with kettle holes.

PLEISTOCENE - The earlier of the two epochs comprising the Quaternary period. Also called Glacial epoch and formerly called Ice Age.

POINT - The extreme end of a cape or the outer end of any land area protruding into the water, usually less prominent than a cape.

PROFILE, BEACH - The intersection of the ground surface with a vertical plane; may extend from the top of the dune line to the seaward limit of sand movement. (See Figure 10-1.)

PROGLACIAL LAKE - Lake occupying a basin in front of a glacier generally in direct contact with the ice.

PROGRADATION - A seaward advance of the beach berm.

PROPAGATION OF WAVES - The transmission of waves through water.

QUARTZITE - A granulose metamorphic rock consisting essentially of quartz.

RADIOCARBON DATING - The determination of the age of a material by measuring the propagation of the isotope C^{14} (radiocarbon) in the carbon it contains. The method is suitable for the determination of ages up to a maximum of about 30,000 years.

RECESSION (OF A BEACH) - (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also RETROGRESSION.

RECESSIONAL MORAINE - A moraine formed during a temporary decrease in the rate of glacial retreat.

RECHARGE - The processes by which water is absorbed and is added to the zone of saturation. Also, the quantity of water that is added to the zone of saturation.

RECURVED SPIT - A SPIT having one end more or less strongly curved inward (landward).

REFRACTION (OF WATER WAVES) - (1) The process by which the direction of a wave, moving in shallow water at an angle to the contours, is changed. The part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest to bend toward alignment with the underwater contours. (2) The bending of wave crests by currents.

RETROGRADATION - The cutting back of a beach toward land.

RETROGRESSION (OF A BEACH) - (1) A continuing landward movement of the shoreline. (2) A net landward movement of the shoreline over a specified time. Also RECESSION, RETROGRADATION.

REVETMENT - A facing of stone, concrete, etc., built to protect a scarp, embankment or shore structures against erosion by wave action or currents.

RIP CURRENT - A strong surface current flowing seaward from the shore. It usually appears as a visible band of agitated water and is the return movement of water piled up on the shore by incoming waves and wind. With the seaward movement concentrated in a limited band, its velocity is somewhat accentuated.

RIPPLES (BED FORMS) - Small bed forms with wavelengths less than 1 foot and heights less than 0.1 foot.

RIPRAP - A layer, facing or protective mound of stones randomly placed to prevent erosion, scour or sloughing of a structure or embankment; also the stone so used.

RUBBLE - (1) loose angular waterworn stones along a beach. (2) Rough, irregular fragments of broken rock.

RUBBLE-MOUND STRUCTURE - A mound of randomly shaped and randomly placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (*Armor units in primary cover layer may* be placed in orderly manner or dumped at random.)

SALTATION - That method of sand movement of randomly shaped and randomly placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in primary cover layer may be placed in orderly manner or dumped at random.)

SALTATION - That method of sand movement in a fluid in which individual particles leave the bed by bounding nearly vertically and, because the motion of the fluid is not strong or trubulent enough to retain them in suspension, return to the bed at some distance downstream. The travel path of the particles is a series of hops and bounds.

SALT MARSH - A mud flat that has reached sea level enabling salt-tolerant plants to grow, thus producing a tough, erosion-resistant vegetal mat that reaches approximately the level of high tide.

SAND - Detrital material ranging in size from 2 to 1/16 millimeters in diameter.

SANDFILL - Sand added to a beach as a shore-protection measure.

SCARP - A more or less continuous line of cliffs or steep slopes facing in one general direction that are caused by erosion or faulting. (See Figure 10-1.)

SCARP, BEACH - An almost vertical slope along the beach caused by erosion by wave action. It may vary in height from a few inches to several feet, depending on wave action and the nature and composition of the beach. (See Figure 10-1.)

SCOUR - Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

SEA CLIFF - A cliff situated at the seaward edge of the coast and formed by wave action.

SEAS - Waves caused by wind at the place and time of observation.

SEAWALL - A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action.

SEDIMENT - Solid material, both mineral and organic, that is in suspension, is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface either above or below sea level.

SEDIMENTARY ROCKS - Rocks formed by the accumulation of sediment in water (aqueous deposits) or from air (eolian deposits). The fragments or particles are of various sizes (conglomerate, sandstone, shale), of the remains or products of animals or plants (certain limestones and coal), of the product of chemical action or of evaporation (salt, gypsum, etc.) or of mixtures of these materials. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratificaiton. Each layer is a bed or stratum. Sedimentary beds as deposited lie flat or nearly flat.

SEPTAGE - The solid waste from on-site septic systems.

SHALLOW WATER - (1) Commonly, water of such a depth that surface waves are noticeably affected by bottom topography. It is customary to consider water of depths less than one-half the surface wavelengths as shallow water. See DEEP WATER. (2) More strictly, in hydrodynamics with regard to progressive gravity waves, water in which the depth is less than 1/25 the wave-length. Also called very shallow water.

SHINGLE - (1) Loosely and commonly, any beach material coarser than ordinary gravel, especially any having flat or flattish pebbles. (2) Strictly and accurately, beach material of smooth, well-rounded pebbles that are roughly the same size. The spaces between pebbles are not filled with finer materials. Shingle often gives out a musical sound when stepped on.

SHOAL (noun) - A detached elevation of the sea bottom, comprised of any material except rock or coral, which may endanger surface navigation.

SHOAL (verb) - (1) To become shallow gradually. (2) To cause to become shallow. (3) To proceed from a greater to a lesser depth of water.

SHORE - The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a beach. (See Figure 10-1.)

SHORELINE - The intersection of a specified plane of water with the shore or beach (e.g., the high-water shoreline would be the intersection of the plane of mean high water with the shore or beach.) The line delineating the shoreline on U.S. Coast and Geodetic Survey nautical charts and surveys approximates the mean high-water line.

SHORELINE-BREAKER ANGLE - The angle that a breaking wave makes with the shoreline.

SILICIFIED - Replaced by or having the interstitial spaces filled with fine-grained silica.

SILT - A very fine-grained sediment, most of the particles of which are between 1/16 and 1/256 millimeters in diameter.

SLIP FACE - The steep, leeward side of a migrating dune.

SLUMP - The downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as subsidiary units, usually with backward rotation of a more or less horizontal axis parallel to the cliff or slope from which it descends.

SORTING - (1) In a genetic sense the term may be applied to the dynamic process by which material having some particular characteristic, such as similar size, shape or specific gravity, is selected from a larger heterogeneous mass. (2) In a descriptive sense the term may be used to indiate the degree of similarity, in respect to some particular characteristic, of the component parts in a mass of material.

SORTING COEFFICIENT - A mathematical measure of the degree of sorting of a sediment.

SPIT - A small point of land or a narrow shoal projecting into a body of water from the shore.

SPUR - A short section of sand fence attached to and perpendicular to a longer section that is parallel to the beach.

STEM - The ascending axis of a plant, whether above or below ground, which ordinarily grows in an opposite direction to the root or descending axis.

STILLWATER LEVEL - The elevation that the surface of the water would assume if all wave action were absent.

STRATIFIED - Formed or lying in beds, layers or strata.

STRATIFIED DRIFT - Drift exhibiting both sorting and stratification, implying deposition from a fluid medium such as water or air.

STRATIGRAPHIC - Of, relating to or determined by stratigraphy. The study and correlation of stratified rocks according to origin, composition, distribution and succession of strata.

SURFICIAL GEOLOGY - The study of materials formed on, situated at or occurring on the earth's surface (especially unconsolidated residual, alluvial or glacial deposits lying on the bedrock).

SURF ZONE - The area between the outermost breaker and the limit of wave uprush.

SWASH - The rush of water up onto the beach face following the breaking of a wave.

SWELL - Wind-generated waves that have traveled out of their generating area. A swell characteristically exhibits a more regular and longer period and has flatter crests than waves that are near their area of generation.

TERMINAL GROIN - A groin placed (usually at the beginning or end of a proposed project) about 1 foot above the surface. See GROIN.

TERMINAL MORAINE - A moraine formed across the course of a glacier at its farthest advance, at or near a relatively stationary edge or at places marking the termination of important glacial advances.

TIDAL CURRENT - The alternating horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide producing forces. See also FLOOD CURRENT AND EBB CURRENT.

TIDAL, RANGE - The difference in height between consecutive high and low (or higher high and lower low) waters.

TIDE - The periodic rising and falling of the water that results from gravitational attraction of the moon and sun and other astronomical bodies acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as TIDAL CURRENT, reserving the name TIDE for the vertical movement.

TILL - Unsorted, unstratified sediment carried or deposited by a glacier.

TOPOGRAPHY - The configuration of a surface, including its relief, the position of its streams, roads, buildings, etc.

TROPICAL CYCLONE - See HURRICANE.

TROPICAL STORM - A tropical cyclone with maximum winds less than 75 miles per hour.

TURBULENT FLOW - That type of flow in which the stream lines are thoroughly confused through heterogeneous mixing of flow as opposed to laminar flow in which the stream lines remain distinct from one another over their entire body.

UNCONFORMABLY - Not succeeding the underlying strata in immediate order of age and in parallel position.

UNSTRATIFIED - Not formed or deposited in beds or strata.

WASHOVER - Small delta built on the landward side of a bar separating a lagoon from the open sea. A washover results from storm waves breaking over low parts of the bar and depositing sediment on the lagoon side.

WASHOVER CHANNEL - Depression leading across a low dune from the ocean side to the washover on the lagoon side. Formed when a wave breaches a low dune.

WATER TABLE - The upper surface of a zone of saturation, except where that surface is formed by an impenetrable body.

WAVE - A ridge, deformation or undulation of the surface of a liquid.

WAVE DIRECTION - The direction from which a wave approaches.

WAVE ENERGY FLUX - The rate at which energy is transmitted in the direction of wave propagation across a plane perpendicular to the direction of wave advance and extending down the entire depth.

WAVE FRONT - On a wave refraction diagram, a line drawn parallel to the wave crests or perpendicular to the wave rays. (See Figure 10-3.)

WAVE HEIGHT - The vertical distance between a crest and the preceding trough.

WAVELENGTH - The horizontal distance between similar points on two successive waves measured perpendicular to the crest. (See Figure 10-2.)

WAVE PERIOD - The time for a wave crest to traverse a distance equal to one wavelength. The time for two successive wave crests to pass a fixed point.

WAVE RAY - On a wave-refraction diagram, a line drawn perpendicular to the wave crests. Also ORTHOGONAL. (See Figure 10-3.)

WAVE RAY-SHORELINE ANGLE - The angle that an incoming wave ray makes with the shoreline.

WAVE SETUP - Superelevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

WAVE TROUGH - The lowest part of a wave form between successive crests. Also that part of a wave below stillwater level.

WEATHERED - Altered by a group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action, change in character, decay and finally crumble into soil.

WIND SETUP - (1) The vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water. (2) The difference in stillwater levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water. (3) Synonymous with STORM SURGE. STORM SURGE is usually reserved for use on the ocean and large bodies of water. WIND SETUP is usually reserved for use on reservoirs and smaller bodies of water.

WINDWARD - The direction from which the wind is blowing.

WISCONSIN - Fourth Pleistocene epich of glaciation.

SOURCES

Definitions in this glossary came from the following sources:

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U.S. Army Coastal Engineering Research Center, 1975. Shore Protection Manual. Three Volumes. U.S. Army Coastal Engineering Research Center, Kingman Building, Fort Belvoir, Virginia.

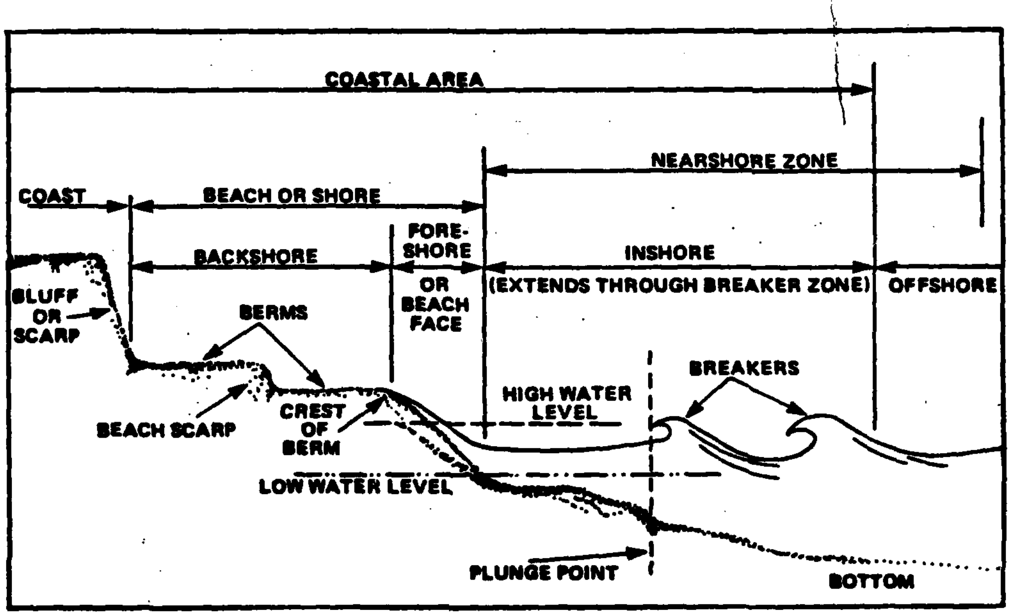

Figure 10-1. Beach Profile-Related Terms (after U.S. Army Coastal Engineering Research Center, 1975)

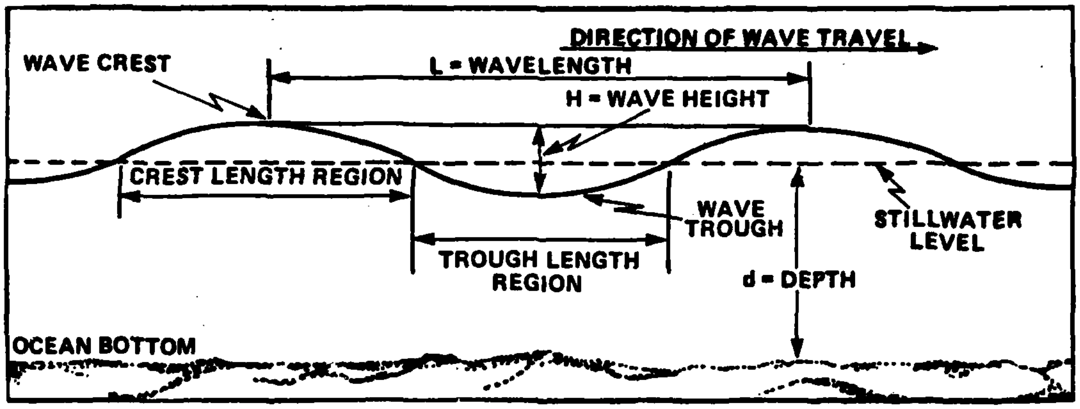

Figure 10-2. Wave Characteristics and Direction of Water Particle Movement (after Wiegel, 1953).

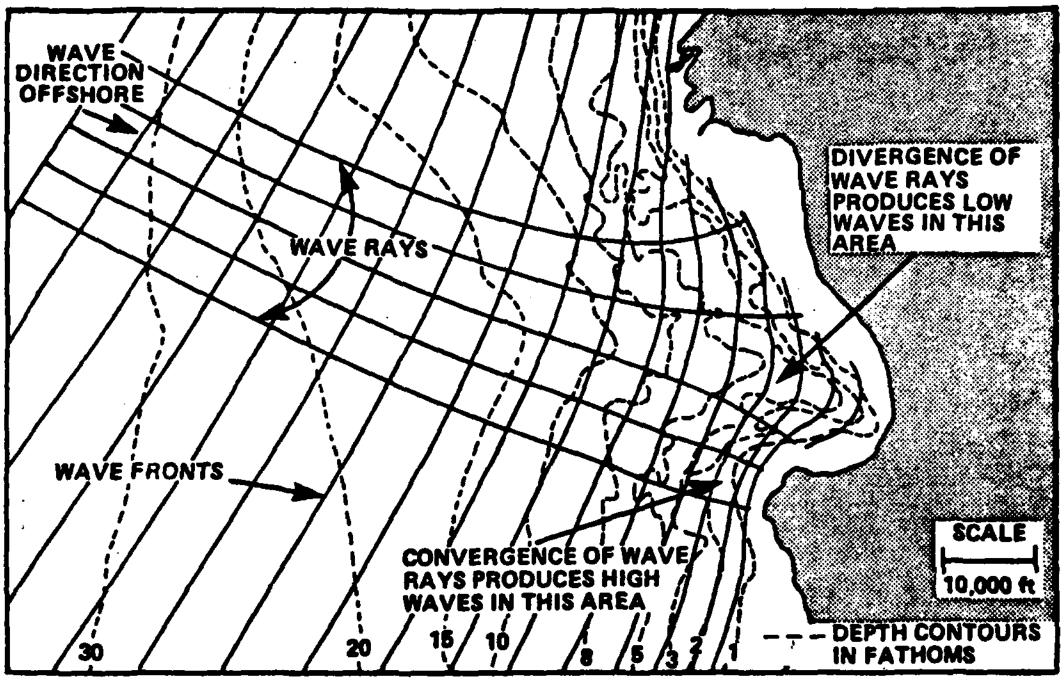

Figure 10-3. Refraction Diagram (after Wiegel, 1953)

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